SCIENCE

30 September 1960

Vol. 132, No. 3431

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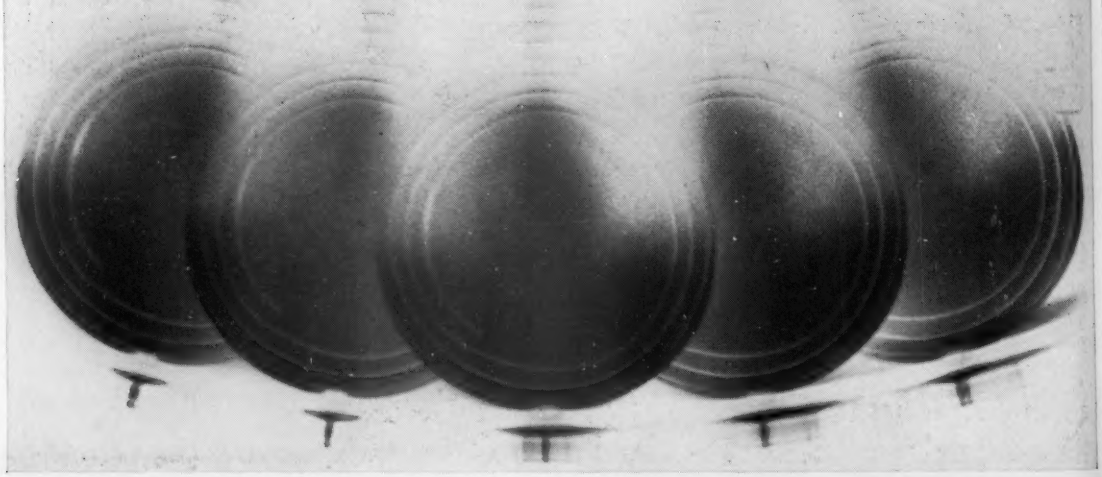

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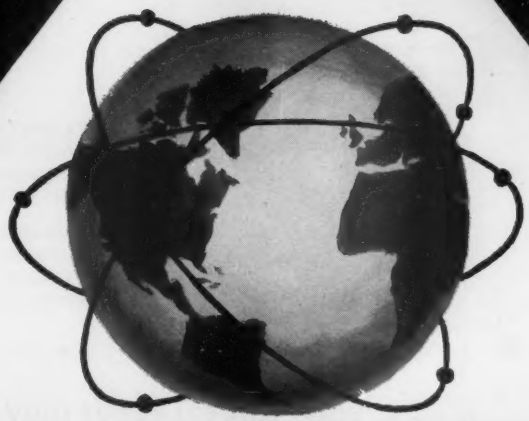

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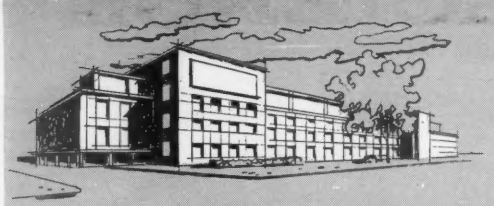
Cover Electron micrograph of the wall of a grain of grass pollen (*Poa annua* L.), made from a thin section of the germinal pore shadowed with platinum. The wall runs from the lower left to the upper right. Of the layers of the wall, the exine is darkest, the mesine is nearly as dark but textured, and the intine is light, similar to the background (left). The cytoplasm is to the right. In the center of the wall is a pore cut medially with an oval plug of exine, overriding a very thin layer of mesine, and the bulging intine (× 25,000). The micrograph was made at the Swiss Federal Institute of Technology, Zurich. [John R. Rowley, University of Massachusetts]



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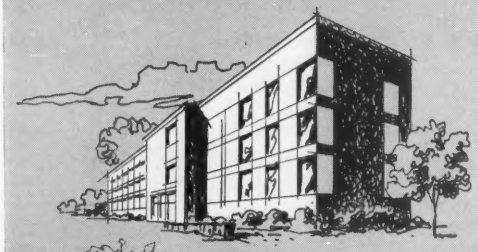
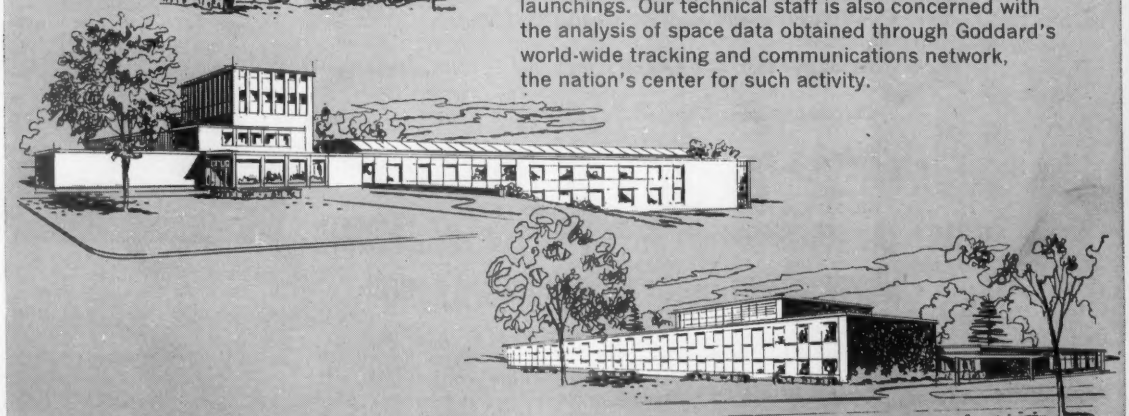


The Goddard Space Flight Center has just occupied an ultra-modern research complex situated on 550 acres of rolling parkland in Greenbelt, Maryland, a residential suburb of Washington, D.C. Here, many of our scientists and engineers work to advance space science and technology through a broad program of theoretical study, while others design, develop and construct scientific payloads for space vehicles and supervise their launchings. Our technical staff is also concerned with the analysis of space data obtained through Goddard's world-wide tracking and communications network, the nation's center for such activity.



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SCIENCE, which is now combined with THE SCIENTIFIC MONTHLY, is published each Friday by the American Association for the Advancement of Science at National Publishing Company, Washington, D.C. The joint journal is published in the SCIENCE format. SCIENCE is indexed in the *Reader's Guide to Periodical Literature*.

Editorial and personnel-placement correspondence should be addressed to SCIENCE, 1515 Massachusetts Ave., NW, Washington 5, D.C. Manuscripts should be typed with double spacing and submitted in duplicate. The AAAS assumes no responsibility for the safety of manuscripts or for the opinions expressed by contributors. For detailed suggestions on the preparation of manuscripts and illustrations, see *Science* **125**, 16 (4 Jan. 1957).

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Annual subscriptions: $8.50; foreign postage, $1.50; Canadian postage, 75¢. Single copies, 35¢. Cable address: Advancesci, Washington.

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Who Calls the Tune?

One of the most effective ways for scientists to exchange information and keep abreast of new developments is by way of scientific meetings. International scientific meetings are of especial importance and pose peculiar difficulties because of national policies that interfere with the free movement of scientists from one country to another. Foreign scientists sometimes have trouble getting visas to come to this country, and sometimes they find it impossible. This is one problem, but it is not the only one. Some of our scientists—government scientists—find themselves subject to a special ruling that limits their freedom to attend meetings abroad. This special limitation applies to international meetings that will be attended by scientists from countries not recognized diplomatically by the United States. Before a government scientist can attend such a meeting as a participant or at government expense, the State Department must be satisfied that no scientist from any nonrecognized country will be present. If any scientist from a nonrecognized country plans to attend the meeting, then our government scientists may not go unless they pay their own way. Even if they do pay their own way they may not deliver a paper at the meeting.

The State Department justification for the policy is this: if scientists employed by the government should attend meetings along with scientists from, for example, East Germany or Communist China, our policy of nonrecognition would be weakened. The supporting argument is that nonrecognized countries would make the propaganda claim that our scientists are government officials and that consequently their attendance at meetings with representatives from these countries constitutes *de facto* recognition.

Whatever the merit of the diplomatic issue, it ought to be weighed against the losses that the ruling entails. It is not the individual government scientist alone who loses; the agency that assigns him to attend the meeting is acting in the national interest, and that also suffers. Do we stand to lose more than we gain by our policy? In one way we clearly do. By the simple expedient of sending a representative to a meeting, a nonrecognized country can block the attendance of our government scientists. We thus allow our participation to be governed by these countries rather than by our own national interest.

Another objection to the argument in support of the policy is that even though the scientists in question do work for our government, they do not represent us diplomatically. Thus the presence of government scientists at a meeting of the kind being discussed cannot reasonably be construed—despite the State Department's apprehensions—as a step toward recognition. The International Council of Scientific Unions in 1958 passed a resolution affirming the right of scientists to participate in international scientific activity "without regard to race, religion, or political philosophy" and added that such participation "has no implications with respect to recognition of the government of the country or territory concerned." In April 1960 the Governing Board of the National Academy of Sciences–National Research Council endorsed that resolution.

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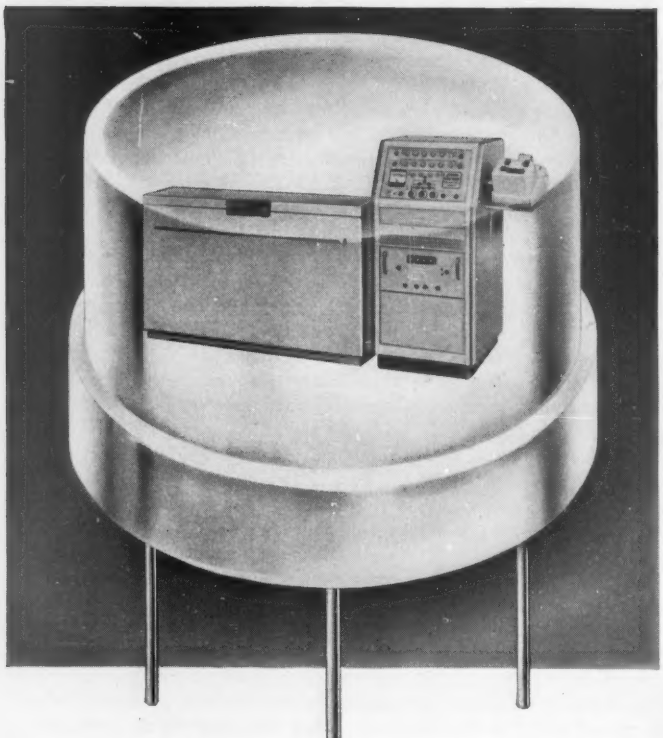

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SCIENCE

CURRENT PROBLEMS IN RESEARCH

Random Processes in Control and Communications

The application of some very pure mathematics to some very practical problems has led to new insights.

R. F. Drenick

In the last 15 years or so, some remarkable changes have taken place in the kind of mathematics used in applications and also in the applications which utilize mathematics. A field in which this change is particularly striking is that of communications and automatic control. The upheaval in the thinking of the engineers in this field is profound and apparently far from finished. They have had to adopt a new viewpoint and to learn to use a new set of mathematical tools. In return, they have succeeded in solving new problems and in finding new and more elegant solutions for some old problems. In some cases, areas have been uncovered whose existence was unsuspected until a short time ago, and new realizations have been obtained which have excited attention and interest well beyond the immediate field of control and communications.

An interesting feature of this upheaval is that it draws heavily on what is often called "pure" mathematics, and sometimes called, also, "abstract" or "modern" or even "useless." In any case, this is certainly the kind of mathematics which was developed originally for its own intrinsic interest. Nothing was further from the minds of the people who created it than the idea that it might ever be applied in practice, least of all to something as worldly and practical as communications and control engineering.

This article is a brief, sketchy (and therefore highly inaccurate) story of how theory and application got together in this field and of what came of the alliance.

The "Signal Space"

An engineer in the control or communications field deals fundamentally with two concepts, one which he calls signals and another which he calls transducers. The first are variable voltages, or currents, or similar physical quantities, such as, for instance, the current in some wire in a home television set. The second are devices which change the character of signals. The television set as a whole is such a transducer, and a relatively simple one at that. A digital computer is another and much more complicated one.

What must an engineer do who has decided to reform and to start dealing with his problems in the "new and modern" way? The first thing he should do is to go and see a mathematician and explain his problems. It will then invariably develop that an altogether exasperating language barrier exists between the two. What, the mathematician will ask blankly, is a signal? The engineer will then go to the blackboard and begin rhapsodizing on the subject.

He will say that signals are in a way both the raw materials and the finished products of his technology. He is used to visualizing them as plots of some quantity—voltage, say, versus time, as in Fig. 1*a*. Sometimes he thinks of them in a more stylized form, as what he calls a sampled signal. In this form, shown in Fig. 1*b*, the signal voltage is specified only at certain instants of time, called the sampling instants. This is much simpler than the complete version of Fig. 1*a* and almost as good. In either version, the time marked t is the "present time" beyond which the signal has not yet progressed. The rest the engineer often calls the "past" or the "history" (and sometimes, somewhat redundantly, the "past history") of the signal. He usually visualizes a history as very long, with its beginning way back in dim and unremembered ages, so that it can for practical purposes be taken to be infinitely long.

In some applications, the signal voltage can assume only a discrete number of values, as opposed to the preceding example where any voltage was possible. Such a signal the engineer calls "quantized," and the allowed signal levels are the "quantum levels." These levels can be labeled with numbers, or with letters, as, for instance, the signal in Fig. 2 (which employs a six-letter alphabet).

The engineer has now explained his mental picture of a signal, and he rests his case. The mathematician has begun to see the outlines of the problem. He tells the engineer that he strongly suspects a signal to be a case of what he and his colleagues call a random (or stochastic) process. (Now it is the engineer's turn to look blank.) The mathematician then calmly proceeds to give the engineer's mental picture its first severe jar by telling him that he ought to visualize a signal as a point in an infinite-dimensional space. Now, the engineer vaguely remembers from his college days that spaces come in various dimensions, usually one- or two- or three-dimensional. Four-dimensional spaces are rare but sometimes fashion-

The author is affiliated with the Bell Telephone Laboratories, Murray Hill, N.J. This article is based on a paper presented 28 December 1959 at a symposium on "Trends in the Application of Mathematics," sponsored jointly by Section A of the AAAS and the Society of Industrial and Applied Mathematics, at the Chicago meeting of the AAAS.

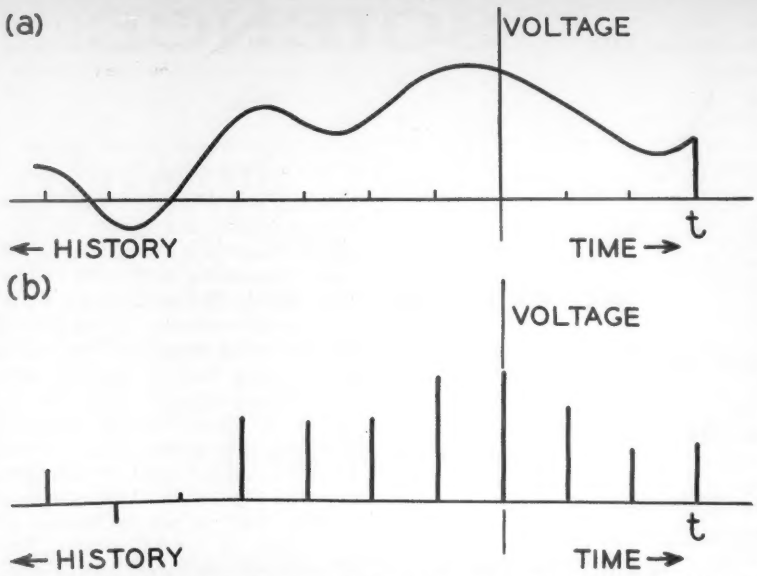

Fig. 1. (*a*) Plot of signal voltage versus time; (*b*) plot of a sampled signal, in which the signal voltage is specified only at certain instants of time.

able, and *n*-dimensional ones are possible if nearly inconceivable. Infinite-dimensional spaces, however, strike him as clearly preposterous. The mathematician, trying hard to hide his condescension, reminds the engineer that the dimensionality of a space is always indicated by the number of coordinates needed to fix the location of a point in it. The engineer concedes. The history of a sampled signal trailing away into the dim dark past is specified (for all practical purposes) by infinitely many voltage samples. The engineer concedes again. Each one of these samples may be considered a coordinate; hence, the signal is specified by infinitely many coordinates and can be thought of as a point in an infinite-dimensional space. Q.E.D., concludes the mathematician. The engineer gives in.

He does so reluctantly at first because he knows only too well from bitter experience that infinities must be approached with the utmost tact and respect, and he feels decidedly uncomfortable at first in his new "signal space." But he is soon engaged by the exhilarating simplicity of it. Every signal which can possibly appear in, for instance, a television receiver, westerns, commercials, dramas, whodunits, quiz shows, experts' panels, puppet shows—each is reduced (perhaps quite appropriately) to the insignificance of a point in a space.

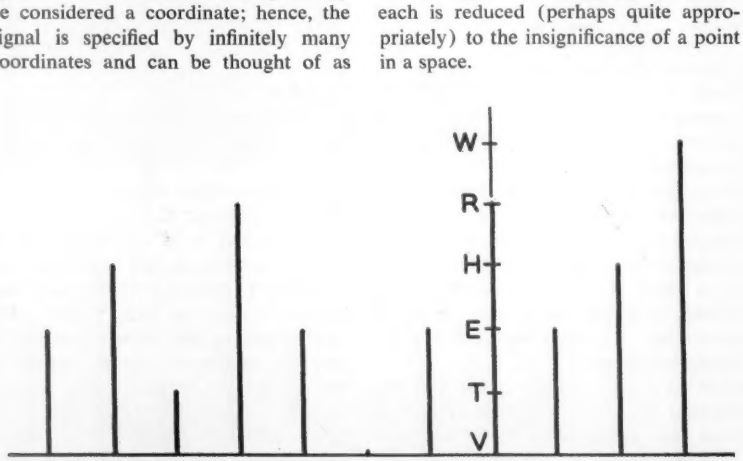

Fig. 2. Plot of a "quantized" signal, in which a six-letter alphabet is used to label the signal levels.

Probability Measures

However, the picture so far proposed by the mathematician lacks some important ingredients. One of its defects is precisely the relative insignificance of the various points of the signal space. For realism, the picture should allow for the fact that some kinds of signals tend to come up more often than others. Whodunits are more likely to appear than dramas, and westerns more likely than either.

The mathematician has just the right remedy for this difficulty: he proceeds to cover the whole signal space, with calm disregard for its magnitude, with what he calls a "probability measure." Like a tremendous blanket, this measure covers every set of points in the space and assigns a certain weight to it—namely, the probability of its occurrence. It assigns a definite probability to all westerns, and among these a definite, though smaller, probability to all psychological westerns, and a smaller one yet to all psychological westerns containing barroom brawls in which a chair is thrown through a great mirror.

Probability measures come in many forms and textures. Some are nice and smooth, as blankets ought to be, but others are lumpy or full of holes (quantized signals, such as the one in Fig. 2, have measures that consist of nothing but lumps). There is one class of measures, however, which are great favorites, partly because of their smoothness and partly because of several other engaging properties. These are the so-called "Gaussian" measures. They are straightforward generalizations of the Gaussian, or normal, probability distribution which is widely used in statistics and which has the well-known bell shape shown in Fig. 3. In communications problems, this curve shows the probability of occurrence of a single nonquantized signal voltage, plotted against that voltage itself.

One can ask next what the joint Gaussian probability of occurrence of the voltages in two adjacent signal samples looks like, and the answer is, a two-dimensional bell shape like the one in Fig. 4. It, too, is a concept much used in statistics. The exact shape of the bell varies from case to case. Typically, it is elliptical. It can be circular, however, as in Fig. 4, and this is a particularly useful case—namely, one in which the two adjacent signal voltages are statistically independent.

One can now go on to three-dimensional bell shapes and four-dimensional

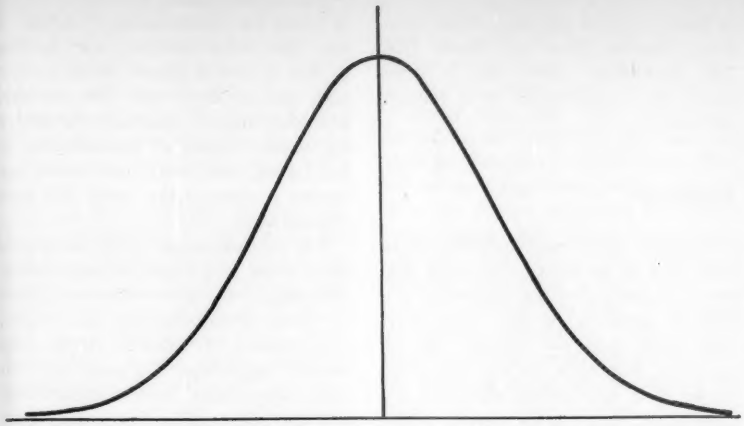

Fig. 3. Plot of the Gaussian probability distribution for a single nonquantized signal voltage.

ones, and so on. The Gaussian probability measure is, in a way, an infinite-dimensional bell shape. It, too, can be elliptical or circular, and in the latter case all signal voltages are statistically independent. Engineers have come to call this the "white" case (for a reason which would be hard to explain here and which is not very good anyway).

Gaussian measures in general, and white ones in particular (Gaussian and otherwise), will figure prominently in our story.

Borel Fields

The idea of a probability measure usually fits rather nicely into the intuitive notion an engineer has of a signal space, and there is usually little trouble in persuading him to adopt it. Little does he know that he has let himself be talked into an upheaval in his way of thinking.

The cue he missed lies in the word *set*, which was slipped in unobtrusively at the start of the preceding section. As it happens, single points in signal spaces are usually quite uninteresting. A point is, for instance, a very long television program, specified to the minute detail of every one of its signal-voltage samples. Two such programs which are exact copies of each other except for a small difference in one of their signal voltages are two different points in signal space. It is clear that a single point is too insignificant an item to have any appreciable probability of occurrence. It is only sets of many points that are worth talking about.

As far as the engineer is concerned, this means that he must learn to think in terms of point sets in signal space. This will be a new and possibly traumatic experience for him. The mathematician will tell him that sets can be operated on by forming unions between pairs of sets, and also intersections, and that in fact not only pairs but finitely and infinitely many sets can be involved in these operations.

The mathematician will further reveal that he and his colleagues like to work with families of sets, which they call Borel fields. These families are so large to begin with that the forming of unions and intersections, no matter how often it is repeated, can never produce extrafamilial offspring. This is a safety precaution rather than some form of mathematical morality, for it allows the mathematician to perform set operations ad infinitum without having to worry about straying outside the family.

To a mathematician, it is the combination of the three concepts—the signal space, the probability measure, and the Borel field—which makes up what he calls a "random process." Thus, if the measure is Gaussian, he will speak of a Gaussian random process, and if the sample voltages are statistically independent, he will often call it a white random process. The engineer, by now totally overwhelmed by the flood of new concepts, can think of no reason for not doing the same. He now calls his signals random processes, and is proud of them.

The feeling of comfort and togetherness, however, which pervades a mathematician when he is working in Borel fields usually fails to envelop the engineer. On the contrary, he finds Borel fields irritatingly useless and completely unmanageable. They have turned his neat signal space into a nightmare of blobs, called sets, which are continuously and uncontrollably splitting up and melting together again. The solid ground to which he is accustomed, and on which he is widely known to have both feet, has been replaced with some shifty quicksand-like material. Borel fields, he feels, may be all right for mathematicians but they definitely are not the stuff on which to build a technology.

On closer inspection, however, they often reveal some surprising structure which is as permanent and firm as structures can be. This comes from the

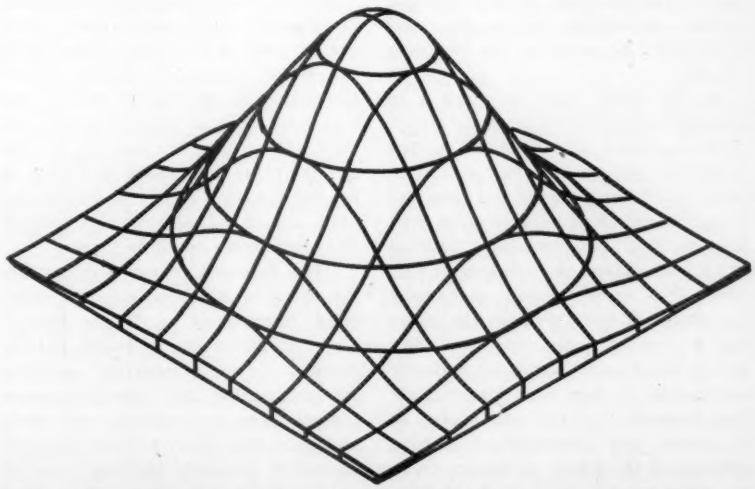

Fig. 4. Plot of the joint Gaussian probability distribution for nonquantized signal voltages in two adjacent signal samples.

fact that a Borel field consists of sets which consist of histories which, in turn, consist of many samples. It is these samples which are in the end responsible for the structure. Every history contains a most recent sample, which is the most recent event in the past of that particular signal. Events such as this one, skimmed collectively from all signals in the space, form a layer of sets which lies across the Borel field of all histories like a thin sediment deposited by time on a huge bed of earlier ones. A similar layer, just beneath the most recent one, corresponds to the sample immediately prior to the most recent one; and so on. What results from this is a distinct stratification of the Borel field into infinitely many layers, one layer per sample of history.

The mathematician, or engineer, can now engage in what can only be called "mathematical archeology." An archeologist digging into the site of some ancient dwelling place often removes layer after layer of successive cultures, each layer telling through its artifacts and ashes some of the history of the locale. Similarly, the mathematician can peel layer after layer from his Borel fields and work deeper and deeper into the history buried in the signal space. Archeologist and mathematician alike must work carefully to be sure not to disturb an earlier layer whenever they remove a later one. To the mathematician, this means that he must make sure of the statistical independence of a layer before he dare remove it. Other than that, however, he has few troubles. He need not worry about sandstorms, theft, or local revolutions. He can dig without obstacle further and further into the past, until in the limit he comes to the beginning of time.

At this point, however, there is an awesome surprise awaiting him. He expects, no doubt, that when he reaches it, history will be exhausted, the Borel fields will be empty. But this need not be so. It can happen, and often does happen, that there remains a residual Borel field, remote and unapproachable, which has some almost apocalyptic properties. It is quite unlike the layers that he has removed previously. The signals which issue from it are perfectly predictable. If they ever existed at all, they continue to exist and evolve in a precise and foreordained fashion through all the layers of history up to the present and on into the future. Nothing that can happen in the course of history can in any way affect them. Once sounded, they ring forever true. This prehistoric Borel field is often called the "remote past" of a random process.

Transducers

Engineer and mathematician have now come to see eye to eye on the subject of signals, the raw materials and finished products of the technology. They must next get together on the machines that work on the materials. As we have said earlier, these are the transducers; they are the devices which convert one signal into another.

A transducer, the engineer will explain, has one signal going into it, called the input, and another one coming out of it, called the output. (Sometimes there are more than one of either.) Each possible input is a point in a signal space, which is now, understandably, called the input space; the outputs are points in an output space.

Many transducers have two outstanding properties. (i) They are "retrospective" (also called "causal"). That is, the present output cannot depend on the future of the input. This is quite an essential property. It says in effect that no physical device can respond to a stimulus that has yet to be applied. (ii) They are one-one, which means that every point (signal) in input space corresponds to one and only one point (signal) in output space. This is not really as essential a property as the first and is actually violated quite often in practice.

To the mathematician, a transducer is a transformation and a rather special one at that. It transforms input space into output space and, in the process, transforms the probability measure and the Borel field of input histories into their counterparts for the output. He can truly say that much is known in the mathematical theory of transformations, but he will also have to concede that much more could be known.

Great favorites among engineers are the so-called linear transducers, more often referred to as "linear filters." They are the easiest to design and the cheapest to build, relatively speaking, and the control and communications systems now in existence use them lavishly. Linear filters have the pleasant theoretical property that the sum of two input signals generates the sum of the corresponding output signals. This is called the superposition principle. It may not seem essential, but the fact is that it makes linear filters particularly easy to deal with. The standard procedure used by engineers for analyzing filters consists of resolving the input signal into many sine waves and tracing it through the filter, sine wave by sine wave.

The mathematician's equivalent to a linear filter is a linear transformation, obviously, and the mathematical theory of linear transformations has seen a vast amount of research, from some humble beginnings 200 years ago and more, up to some highly sophisticated and abstract work in recent decades. It is not overly surprising, therefore, that the first contact between the engineer and the mathematician took place in this area of random process theory.

Wiener's Prediction Theory

The contact was established by a small booklet in yellow paper cover (promptly dubbed the "Yellow Peril" by engineers), written in 1942 by N. Wiener. He was the first mathematician to diagnose some of the engineer's problems, or at any rate the first one to suggest a treatment along the lines I have described above. He prescribed a healthy dose of signal spaces, complete with Borel fields and probability measures, and some gentle applications of transformations. From among the latter he chose the engineer's favorite, the linear filters. Under these circumstances, as he further pointed out, the most appropriate probability measure is the Gaussian, which I mentioned above. The reason for this lies essentially in one fact. It so happens that linear filters preserve the Gaussian character of a measure: if it is Gaussian over input space then it will be Gaussian also over output space.

To the engineer, this would have been a poor argument indeed, and it would never have persuaded him to abandon his sine wave approach to linear-filter problems for the statistical one. But Wiener further showed him that a Gaussian random process could be specified by a quantity (the so-called "spectral density") which is very closely related to his cherished sine waves. What suspicion remained in the engineer's mind was swept away by a final demonstration—namely, that he could calculate by a very simple formula the spectral density of the output of a

linear filter from that of the input. In other words, the engineer was shown that, by adopting Wiener's approach, he could do many of the things he had been doing before and that he could do them in a conceptually much more satisfying way.

Beyond that, however, the new theory provided him with some novel and most revealing insights into the foundations of his technology. It showed him that there are some things which he can hope to accomplish with linear filters, disregarding perhaps certain practical complications, but that there are others he cannot under any circumstances hope to achieve.

He cannot, for instance, hope to ever build a filter which will generate an output with a remote past from an input that lacks one. In order to do that he would have to construct a filter that anticipates the future (that is, one which violates the basic requirement of causality), and this is no more possible than building a perpetual-motion machine.

Beyond generating remote pasts, however, there is little that linear filters cannot do to Gaussian random processes. In fact, one of the central theorems is that, given any two such processes (both without remote pasts), one can always find a linear filter which will accept one of them as input and generate the other as output, and vice versa. One can put this slightly differently by saying that all Gaussian processes form a class whose members are freely transformable into each other by linear filters. It is then customary to let one member of the class represent all others, and a particularly distinguished senior member is picked for the purpose—namely, a white Gaussian random process.

The main objective of Wiener's theory was the problem of predicting the future of a Gaussian random process from knowledge of its past. Wiener showed first of all that the best predictions could always be made by a linear filter. It is useless to try to improve on that by any devices, no matter how ingeniously they are contrived—and this includes tea leaves, gypsy women, and astrologers. A properly designed linear filter simply cannot be beaten for quality and consistency of performance when it comes to predicting Gaussian processes.

The predicting filter accepts as input the process that is to be predicted and generates as output the best guess of what the future will be. The guess will usually be in error by some amount, but on the average it will be as good as or better than any other forecasting procedure for Gaussian processes. In one case, however, the predicting filter will be dead right every time—namely, when the process originates completely in the remote past. For in this case, as we have said before, the process is perfectly predictable to begin with.

In either case, the filter goes about its guessing business in such a clever way that gypsy women might have trouble imitating it. It first transforms the input into a white process, the senior member of the class—and this is always possible, as we know. In the white form, a novel feature appears: part of the original input turns out to be perfectly predictable and part of it completely unpredictable. The predicting filter now proceeds with cold logic. It bases its forecast on the perfectly predictable part exclusively and ignores the rest. Since the rest is totally unpredictable, it is useless anyway, and the prediction error caused by its omission is unavoidable.

All this is concerned with Gaussian processes and linear filters only. The extent to which Wiener's theorems apply to more general processes and transducers is not known. Many people suspect that most of them carry over, but no satisfactory theory exists which demonstrates this.

Shannon's Information Theory

There is, however, a handsome body of theory which holds for very general processes and transducers. This is C. E. Shannon's information theory.

The questions which led to the development of information theory are different from those dealt with by Wiener. One starts out by assuming again that a certain type of signal is given, or, more precisely, a random process complete with signal space, probability measure, and Borel field. It need not be Gaussian. In fact, it will be convenient in what follows to assume that the signal is a quantized one, looking, for example, like the one in Fig. 2. It is true, as I mentioned above, that this forces on us an extremely lumpy probability measure and some attendant discomfort, but it does make explanations here a little easier.

Information theory was developed to answer questions such as these: Is it possible to define some quantity, some single number, which would measure somehow the information conveyed on the average per sample of a signal? What properties should this quantity have and in what units should it be measured? How is it affected when the signal is passed through a transducer? How is it affected if it is passed through a communications channel with noise—that is, a channel in which the signal is distorted, mutilated, or drowned in interference? Are there ways of combating the effect of noise?

The answer to the first question is affirmative. Intuitively we know that the information conveyed by a signal lies in its surprise value. The message "Fire!" in a movie house is more informative than "Coming Attractions." The more surprised one is over receiving a particular signal, the greater, one can say, is the amount of information conveyed by it. On the other hand, the more certain the future value of a signal sample is, on the basis of the history that has preceded it, the less surprising it is, and the less information it conveys when it actually arrives. A signal, for instance, with seven quantum levels labeled "Monday," "Tuesday," and so on, conveys no information at all when it tells us that today is Tuesday if we knew already that yesterday was Monday.

These intuitive notions of the information content of a signal can be put in a more definite form. We now surmise that a signal will be most informative if, for one thing, all of its samples are statistically independent or, to use our present terminology, if it is white. The known history will then in no way compromise the surprise value of the sample scheduled to arrive next. For another, the probability of occurrence for the quantum levels of an individual sample should be as nearly equal as possible. On the other hand, if the history of a signal completely determines its future, if nothing can possibly happen that could not be anticipated, or in still other words, if the signal is perfectly predictable, then it conveys no information at all.

Surprisingly, these two requirements (the conditions under which it should be a maximum and those under which it should be zero), plus a third one of somewhat more involved nature, suffice to define uniquely a quantity which measures the mean amount of information per sample of a random process. As it happens, it is almost exactly what

physicists since the days of Boltzmann have been calling the "entropy."

The main achievement of information theory, however, lies not in merely defining a quantity of information but in showing that it has some most remarkable properties. To begin with, the theory shows that this quantity remains unaffected when a signal is passed through a transducer. This is most satisfying because one feels intuitively that a one-to-one transformation, no matter what it does to a signal, should not affect the information content.

The second important result is this: given two random processes (signals) with the same information content per sample, it is always possible to find a transducer which transforms one signal into the other.

The practical difficulties of constructing the necessary transducer may be quite formidable. But it is clear that, in principle at least, all signals with equal information content form a class whose members are freely negotiable among themselves through the use of suitable transducers.

This theorem is very reminiscent of one of Wiener's which I have mentioned, and the similarity goes in fact even further. For, among all these negotiable class members, there is one particularly distinguished senior member, and this is the one which is white and which has quantum levels of equal probability of occurrence. This is the one which, as I said above, carries the most information per sample. We can now say, further, that it is the one member in the class which can get along with the fewest samples per second or with the fewest quantum levels per sample. It is the most efficient member of the class. Where the others are "redundant," in the engineer's vernacular, this one wastes no words and gives its messages in the most laconic and abrupt of telegraphic styles.

The usefulness of this class concept lies in the following fact: Many communications channels, in practice, can accept only certain kinds of signals, and only at certain limited sample rates. In other words, a channel can be characterized by the kind of signal which it is designed to carry and by the sample rate which it can accept. However, along with this design signal the channel can be forced to carry any other signal, provided only that it belongs to the same class as the design signal. For, as we now know, any signal from this class can be freely transformed (or "encoded," as engineers are apt to say) into the design signal by a suitable transducer. This assertion is the essence of one of Shannon's famous coding theorems—namely, the one for the so-called noiseless channel.

Another, even more famous, coding theorem applies to noisy channels—that is, to channels in which the signal is distorted by some interference. It stands to reason that in such channels some information will always be lost because of the interfering noise, and this is actually so. One can, and in fact does, express the signal degradation by a single number—namely the loss of information content, and calls it the "equivocation" due to noise.

It is tempting at this point to speculate as follows. Since a noisy channel will inevitably lead to some loss of information, some equivocation, in the signal, is it perhaps possible to "enrich" the signal artificially prior to its transmission? In other words, can one somehow raise its initial information content by injecting into it some extra but irrelevant information and then let the channel degrade it? It is conceivable that the artificially enriched signal would release to the channel only that information which it did not need in the first place and thus would emerge on the other end as clean and undefiled as it started out. Such a scheme is in fact possible, and this is the assertion of the second coding theorem.

Unfortunately, it is easier to say that this can be done than to find how to do it. The trouble lies with the preparation of the signal prior to transmission. The problem is not only one of how much extra information to inject into the signal prior to its ordeal by transmission. What matters more is that the enriched signal must be fortified against all possible adversities which it may encounter during its passage through the channel. This is somewhat like the speeches of highly placed government officials which ought to be so written that they cannot be misunderstood, no matter how far out of context they are quoted. These problems are very difficult, by all indications, and no altogether satisfactory solutions have been found for them, either by mathematicians working in information theory or by ghost writers working on official speeches.

Conclusion

Our story started out with a main character, the engineer, in search of a solution to his problems. In the first few chapters he played a prominent, if somewhat helpless, role, but toward the end he faded into the background and left the stage to the mathematician. This is no accident but a part of the story's plot. The engineer has in fact returned to his laboratory. He is now engaged in overcoming the countless vicissitudes and irritating complications which must be overcome whenever the grand and sweeping theories of the mathematician are reduced to practice. In the process, he has had to develop many variations on the original theories, some of them similar to their prototypes but others having only the vaguest of resemblances. His patient (and largely anonymous) labor, however, has found the most varied realizations, in automatic pilots and guidance systems, in oil refineries and nuclear reactors, in radars and navigation systems, in telephone and television, and in many others.

The engineer has been joined in his labors by some unexpected and unprecedented company. The theories which had been precipitated mainly by his problems have attracted the interest and activities of physicists, biologists, neurologists, psychologists, and linguists, not to even mention mathematicians. In all these fields the theories have raised at least as many questions as they have answered, and there are now, it seems, more frontiers that are waiting to be conquered than there are conquerors.

Food and Agriculture Organization Completes 15 Years

An international organization helps to bridge the gap between agricultural science and practice.

Ralph W. Phillips

On 16 October 1945, representatives of 34 nations signed the constitution of the Food and Agriculture Organization of the United Nations (FAO) in Quebec, Canada. Thus, these and other nations who have since adhered to the constitution of FAO stated their determination to take separate and collective action to raise levels of nutrition and standards of living of their peoples, to secure improvements in the efficiency of production and distribution of food and agricultural products, to better the conditions of rural populations, and by these means to contribute toward an expanding world economy.

Actually, FAO had its beginning in a 44-nation Conference on Food and Agriculture at Hot Springs, Virginia, in May 1943. This wartime conference, convened on the initiative of President Franklin D. Roosevelt, set up an interim commission with headquarters in Washington, D.C., which functioned until FAO was brought formally into existence at the first session of the FAO Conference in Quebec, nearly two and a half years later. In addition to the 34 nations which adhered to the constitution at the beginning of the Quebec conference, eight other governments had accepted the constitution or had been admitted to membership by the close of that conference, bringing the membership to 42 nations.

Membership in the organization has now increased to 79. In addition, three other countries have been admitted to membership pending their achievement of full independence and their acceptance of the FAO constitution. Also, five colonies and territories have been granted associate membership status.

So the child that was conceived in wartime adversity and was over two years a-borning is now a rather well-muscled teen-age youth striving to serve the food and agricultural interests of a large portion of the nations of the world. Perhaps the 15th anniversary is an appropriate time to take stock of the youth's development and of his capacity to deal with the tasks ahead.

Role of the Organization

The terms *food and agriculture* in the FAO name cover the broad fields of agriculture, fisheries, forestry, and nutrition and the agricultural, economic, and statistical problems related to these fields. Within these fields, it is the task of FAO to assist governments in the development of their programs and projects aimed at improving agricultural production, processing, and distribution. Thus, FAO is in a sense an international extension service with governments as the recipients of its services. Rural peoples, and consumers generally, benefit as information and the advantages of improved services become available to them.

This does not mean that FAO is concerned only with the applications of science. It is also concerned with the development of research in all its fields of endeavor; with the establishment and strengthening of the organizational or administrative structure of research, extension, and other government services to agriculture; and with the economic and social structure wherein the results of research may be applied with maximum benefit and upon which more adequate support for research, extension, credit, and other essential services can be built. But, FAO is not the doer of research, or the conveyer of new knowledge to farmers through extension, or the provider of credit, and so on. Its task is to assist governments in doing these things or in improving their ways of doing them.

The task is large and diverse. Countries vary widely in the kinds of service they need, or can use, from an international organization. This variation is, to a considerable degree, a reflection of their diverse stages of development.

The agricultural revolution in the more highly developed countries during the last few decades has resulted in more efficient farming and greater productivity per person engaged in agriculture. In the United States, for example, the percentage of the total population represented by the farm population has dropped steadily from 34.9 percent in 1910 to 12 percent in 1959. While the capacity to produce has increased enormously in these countries, the underdeveloped countries have been barely able to keep food production abreast of exploding populations. There are many reasons for the vast gap between these groups of countries which I cannot go into here; Paul Hoffman gives a dramatic summary of the resultant world economic situation in *One Hundred Countries—One and One Quarter Billion People.*

As compared with an estimated annual per capita national income of $2075 in the United States, of $1450 in Canada, and of an average of $875 for the United Kingdom, Switzerland, Sweden, Norway, Denmark, and Austria, there are 100 countries and territories in which the income is less than $700. Among these 100 countries and territories there are 52 in which the average annual income is under $100. This latter group includes approximately 70 percent of the world's population. As Hoffman points out, some of the statistics for underdeveloped countries are only informed guesses, and they probably tend to exaggerate the differences between the poorer and the richer countries. But even when allowance has been made for this and other sources of exaggeration, there can be no doubt that the gap between many developed and underdeveloped countries is indeed wide. This gap has tended to grow wider in spite of the substantial efforts which have been made since World War II to assist the underdeveloped countries.

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In this complex world picture, FAO has the task of serving all its member countries, from the least to the most highly developed.

It follows that the underdeveloped countries have been interested in such matters as the technical improvements in agriculture that are necessary if production is to keep pace with population, and in the economic problems relating to markets for the export crops upon which they depend for foreign exchange. Developed countries, on the other hand, have been interested more in problems of international trade; in problems of surplus production, particularly in cases where troublesome surpluses are accumulating; in the ways whereby an international organization can assist in the exchange of information; and in the extent to which FAO can serve as an effective channel for technical assistance to the underdeveloped countries.

So the program has developed in such a way that, while the largest share of the available funds has been devoted to activities aimed at assisting the underdeveloped countries, the developed countries have taken an active part in the Organization and have benefited from many of its activities.

Admittedly, this is a brief account of the complex of world food and agricultural problems, and of FAO's role in assisting its member countries to deal with those problems. However, it does give a broad background against which to consider the kinds of things FAO has done and is doing.

Structure

The subject-matter activities of FAO are reflected in the organizational structure of its headquarters staff; the technical work is grouped under a Technical Department and an Economics Department, with appropriate supporting services and over-all administrative groups.

The present organizational structure, which has been fully in effect only since 1 January 1960, is as follows.

1) A Technical Department, including Divisions for Land and Water Development, Plant Production and Protection, Animal Production and Health, Fisheries, Nutrition, Forestry, and Rural Institutions and Services. Also there is an Atomic Energy Branch attached to the office of the assistant director-general, who is responsible for this department.

2) An Economics Department, also under an assistant director-general, and with Divisions for Statistics, Commodities, and Economic Analysis.

3) A Department of Public Relations and Legal Affairs, under an assistant director-general. This department includes an Information and Public Relations Service, a Publication Service, the Office of Legal Counsel, an Office of Liaison and Protocol, the Rural Legislation Branch, a Conference and Operations Branch, and the library. The library, called the David Lubin Memorial Library, is named after the American whose activities led to the establishment in 1905 of the International Institute of Agriculture. After World War II, that institute's assets (including its library) were absorbed by FAO.

4) A Division of Administration and Finance, under a director.

5) The Office of the Director-General. The director-general, who is elected by the Conference, is assisted by a deputy director-general, a Program and Budgetary Service, two special assistants, and the internal auditor.

Apart from the headquarters staff, there are provisions for regional offices in North America, Latin America, Africa, the Near East, and Asia and the Far East; there are also a few subregional offices. In addition, there are technical assistance teams in many of the underdeveloped countries, and in most cases one member of the team serves as the FAO representative in the country concerned.

In the early years there were subject-matter divisions for Economics, Fisheries, Forestry, and Nutrition. Some leaders, believing in a planning and management role for FAO and advancing proposals such as establishment of a world food board, were stressing economic aspects of agriculture, and the technical aspects were left largely to one side. It was over a year after the formal establishment of FAO in Quebec that an Agriculture Division was initiated. Somewhat later a Rural Welfare Division was established. When postwar scarcities were becoming less troublesome and countries were turning their attention to longer-term commodity problems, a Commodities Division was established, utilizing some personnel from the Economics Division and the secretariat of the International Emergency Food Council, which had been established by FAO.

Early in 1951, when the headquarters of FAO was transferred from Washington to Rome, some consolidation took place. The Commodities Division was abolished, and most of its functions were assigned to the Economics Division. The Rural Welfare Division was also abolished, and its functions were assigned to the Agriculture and Nutrition divisions. Thus, from early 1951 to 1958, there was a reasonably stable period during which five subject-matter divisions (Agriculture, Economics, Fisheries, Forestry, and Nutrition) were responsible for the substantive work. However, owing to the concern of member countries with technical agricultural problems, particularly as expressed in their requests for technical assistance, work in Agriculture expanded more rapidly than in other fields. So it came about that this division was carrying something over half the total work program, when the regular and the technical assistance programs are considered together. It was at this stage that a decision was taken to divide the Agriculture Division into four divisions, plus a branch to deal with the applications of atomic energy to agriculture. At the same time, it was decided to divide the Economics Division into three divisions. These changes led to the present organizational structure that is described above.

It is natural that a new organization should undergo some structural changes as it undertakes to meet the needs of its member countries, and as it achieves a reasonable balance in the emphasis given to the many phases of food and agriculture encompassed in its terms of reference. Also, during FAO's first 15 years, a time of postwar scarcities has given way to a time of troublesome surpluses of certain commodities in the main exporting countries.

To understand the work of FAO it is also necessary to understand that it is an intergovernmental organization, controlled by its member governments and designed to serve those governments. It may be said that there are two FAO's, the countries which make up the organization and the staff which carries out the program of work agreed to by the governments of the member countries.

The Conference is the primary governing body of FAO. It holds regular sessions biennially. Special sessions may be called to deal with emergency or other special problems. Each member government may send one delegate to the Conference and has one vote. The delegates are accompanied by alternates, associates, and advisers, according to the desires of the respective govern-

Trainees from Southeast Asian countries participate in a regional training center on mechanical logging, which was held in the Philippines.

ments. The Conference acts on applications for membership in the Organization, elects member governments to the Council, decides the level of the budget, sets the scale of contributions, reviews and approves the program of work, reviews the state of food and agriculture, takes decisions on administrative and constitutional questions, discusses any special topics that it may include in its agenda, and (when the posts are to become vacant) appoints a director-general and an independent chairman of the Council. It also acts on other matters that may appropriately be brought before it. One such matter was the determination of the permanent site (Rome, Italy) of the Organization's headquarters. Early sessions of the Conference were held in Quebec (1945), Copenhagen (1946), and Geneva (1947). Since that time all sessions have been held at either the temporary headquarters in Washington or the permanent headquarters in Rome.

The Council, representing the 25 member governments elected by the Conference, serves as the governing body between sessions of the Conference. It holds at least one full-scale session each year, in addition to brief sessions just prior to and immediately after sessions of the Conference. An independent chairman, elected by the Conference, presides over Council sessions. Much of the substantive and detailed work assigned to the Council is done by committees—work which leads in many instances to formal council or conference action. There are four standing committees, dealing with program, finance, constitutional and legal, and commodity problems, respectively. In addition to these standing committees, there currently exists an FAO–UNICEF Joint Policy Committee, which was established on an *ad hoc* basis by the FAO Council and the executive board of the United Nations Childrens' Fund (UNICEF) to advise on administrative, financial, and operational problems arising from the joint activities in which FAO and this special arm of the United Nations participate.

Work of the Organization

Broadly speaking, FAO's work is designed to provide countries with opportunities for intercountry consultation and with information and advice, including technical assistance. Within these broad categories various approaches are used, either singly or in combinations of two or more, depending upon the nature of the job to be done.

The Organization provides international and regional forums at both the scientific and technical level and the policy level. Discussions of over-all problems relating to food and agriculture take place in the FAO council and conference sessions, in regional conferences that are held biennially in several of the major regions, and, in more limited subject-matter areas, in the regional fisheries and forestry councils, the International Rice Commission, the Council's Committee on Commodity Problems and its subgroups on grains, rice, cocoa, coconut, citrus fruits, and surplus disposal problems, and in other forums.

On the scientific and technical side, international and regional meetings, group meetings of experts, and other forums provide opportunities for exchange of information and ideas, and in many cases for the planning of coordinated action, on practically all the subjects covered by the ten divisions and the Atomic Energy Branch, which constitute FAO's Technical and Economic departments. In the forums organized by seven of these divisions and in the atomic energy field, major attention is given to scientific developments and their applications in agricultural production, processing, and distribution.

In FAO's early years, considerable emphasis was placed on missions, usually of a few months' duration to various countries to carry out technical and economic surveys and to propose lines for development, either in the broad field of agriculture or in some limited sector of it. Only one such mission has been organized in recent years, and with the advent of the Special Fund, a somewhat different approach has evolved, based on projects. Each project is designed to lay the basis for a development project such as an irrigation scheme, or a training institute, or a research project. The team supplied by FAO may remain in the country for from one to several years.

Much of FAO's direct assistance to governments has been accomplished through sending experts, sometimes for a few months but usually for one or more years, to advise and assist the governments in planning and carrying forward technical projects and economic studies. Most such experts have been financed under the Expanded Technical Assistance Program. As of September 1959, 1773 experts from 40 countries had served in the field for FAO under this program.

Limited amounts of technical supplies, equipment, and literature may also be made available to countries to enable experts serving in those countries to carry forward their advisory activities—in particular, specialized items which are not readily available in the countries receiving assistance. While such equipment and supplies are usually limited to laboratory items, such things as tractors for experimental purposes and vehicles for transporting FAO

An FAO expert, advising on the engineering aspects of the Gal Oya development project in Ceylon, trains Ceylonese in machine-shop techniques.

personnel, or for transporting supplies in special cases such as the desert locust campaign in the Near East, are provided. Also, in a few instances, experimental animals, such as flocks of sheep, have been supplied.

Nationals of the recipient country are trained in varying degrees by practically every expert who carries out an assignment. In addition, training centers are held for junior personnel, and development centers and study tours for senior officials, in order to train the former in specific techniques for carrying forward agricultural projects and to enable senior personnel to exchange ideas and study new approaches as a basis for planning and administering projects in their own countries. Some of these training programs are carried out under the regular budget or under special grants, but most of them have been carried out as regional projects, or in some cases as national projects, under the Expanded Technical Assistance Program. As of September 1959, approximately 100 such centers had been held under this program.

The Organization also provides fellowships for study outside the fellow's home country, primarily as a means of providing technicians and leaders with training needed to carry forward or administer projects upon which advisory assistance has been, or is being, given by experts. Most such fellowships have been granted under the Expanded Technical Assistance Program, the total number awarded as of September 1959 being approximately 1600. A few were awarded in the early years under an UNRRA transfer fund. In recent years the André Mayer Fellowships (named after the French physiologist) were established to foster research, and advanced training in research methods, in connection with projects related to the FAO program. Approximately 12 are awarded each year.

The Organization prepares and publishes many documents containing statistics and summaries of new scientific, technical, and economic findings and other materials for the information of member countries, and in some instances for the guidance of officials in planning and implementing projects for economic development. These publications cover a wide range; there are yearbooks of production and trade statistics; technical publications in many phases of agriculture, economics, fisheries, forestry, and nutrition; reports of meetings and training centers; reports of missions; reports to governments by technical assistance experts; and documentation for various technical and economic meetings and sessions of the Conference and Council. The nature and extent of FAO's publishing activities is indicated by the following list: *State of Food and Agriculture* (a comprehensive review issued annually); *World Food Survey* (issued in 1946 and 1952); *Agricultural Studies* (approximately 50 comprehensive reviews have been issued in this series to date); *Agricultural Development Papers* (for the guidance of agricultural leaders; approximately 65 papers have been issued); *Nutritional Studies* (including 16 major studies); periodicals including the *Plant Protection Bulletin*, a *Monthly Bulletin of Agricultural Economics and Statistics*, the *FAO Fisheries Bulletin*, *World Fisheries Abstracts*, and *Unasylva*; regular statistical volumes, including a *Production Yearbook*, a *Trade Yearbook*, *Yearbook of Fisheries Statistics*, and a *Yearbook of Forest Product Statistics*; and numerous publications in the *Commodity* and *Commodity Reports* series. There are other types of publications as well, but this list should be sufficient to indicate the kinds of information FAO makes available to its member governments.

Another approach is the organizing and servicing of permanent bodies, as arms of FAO, to provide continuing mechanisms for (i) consultation among countries which have common problems and (ii) such cooperative action as the countries concerned may agree to undertake. These arms of FAO include a considerable number of regional and international commissions, in various phases of agriculture, fisheries, and forestry.

Still another approach is the assisting of governments in the preparation and formalizing of conventions aimed at laying the basis for common action. This procedure has been little used; only one such convention—the International Plant Protection Convention—has been prepared and brought into effect under FAO auspices.

Also, FAO staff members maintain contact with leaders in member countries, through correspondence and visits, to obtain information on their problems, to supply information and advice when requested, and to provide background for the effective use of the approaches described above.

These methods provide a great deal of flexibility yet conform to the Organization's terms of reference. In actual practice the various methods are interrelated, and it is often necessary, as I have already pointed out, to use a number of these methods in dealing with any particular problem or set of problems, in order to achieve the most satisfactory results.

Sources of Financing and Shifts in Emphasis

The activities of FAO are financed by governments through three main channels—the FAO Regular Budget, the Expanded Technical Assistance Program, and the United Nations Special Fund. Limited financial support has also been received from other sources.

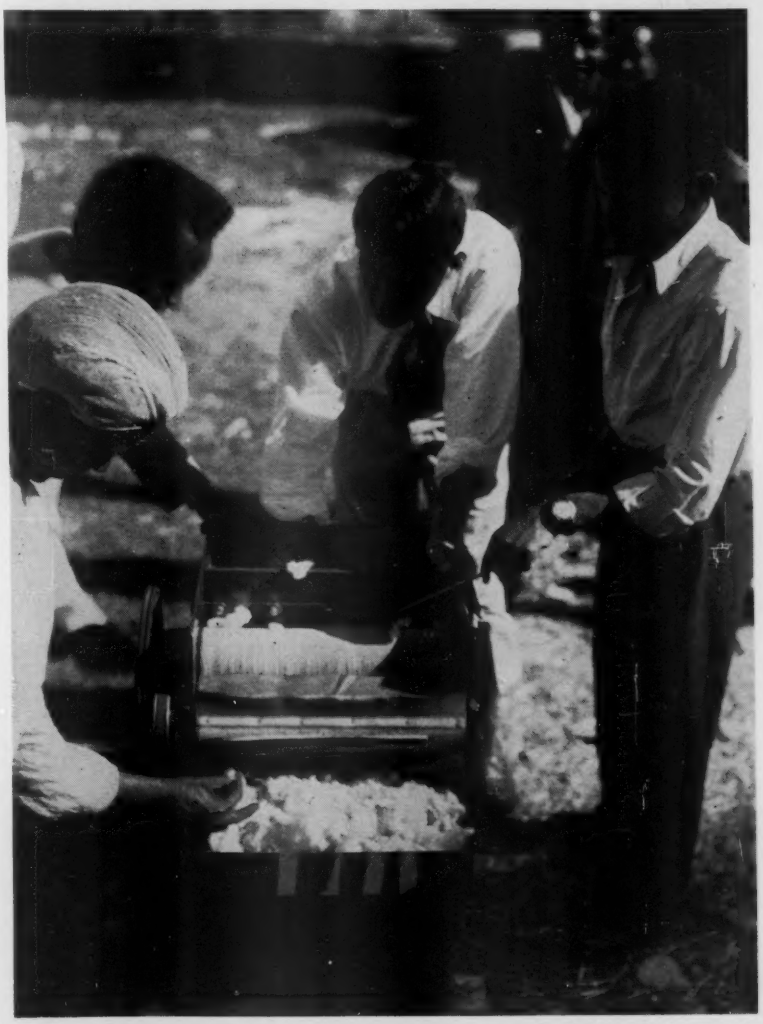
During the first five years, activities were financed largely from the regular budget and consisted mainly of holding international and regional meetings, sending survey missions (at the request of member countries) to study agricultural problems and to propose developments programs, collecting and publishing statistical and technical information, and organizing technical bodies (mostly regional in character, although some—for example, the International Rice Commission—are international in scope) as arms of FAO. Direct technical assistance to member countries was limited largely to brief visits by staff members, to visits of consultants on specific assignments, or to survey missions such as those to Greece, Poland, Thailand, and Nicaragua. Two other aspects of the early work of FAO should also be mentioned here.

During the years immediately after World War II, the Organization serviced an International Emergency Food Council (later renamed "Committee"), which provided the mechanism for voluntary rationing of short supplies of certain agricultural products among countries. Also, much attention was given to proposals for international activities aimed at stabilization of supplies and prices of agricultural commodities. These included proposals for establishing a world food board and an international commodity clearing house. These proposals were not adopted, since governments were not prepared to place this kind of responsibility in the hands of an international agency. The discussions contributed, however, to the decision to set up the FAO Council (replacing an executive committee), with the function, among others, of keeping under review the state of food and agriculture in the world. In practice, this function has been limited largely to consideration of commodity problems by the Council and by the Council's 24-member Committee on Commodity Problems and its subsidiary working groups described above.

Early in 1947, FAO reached an agreement with the then existing United Nations Relief and Rehabilitation Administration whereby UNRRA turned over to FAO something over $1 million for direct advisory assistance in agricultural problems to nine FAO member countries that had been receiving supplies from UNRRA. This supplemented the regular budget, and over a period of several years scientific and technical advisers could be stationed in these countries for fairly long periods. In addition, some fellowships were provided, as well as some equipment and materials to enable the advisers to move ahead with their work.

The amount that each member government and associate member is to contribute to FAO's regular budget is determined by the Conference for each biennium, according to an established formula. For 1960 and 1961 the amount assessed from governments is $18,451,000, or $9,225,500 annually. The United States' share is 32.51 percent, or $2,999,210.05 annually. From the beginning, the regular staff, which has been financed under this regular budget, has provided the backbone of FAO's work and has been the central core around which other phases of FAO's program have developed.

The Organization's second five years may be characterized as the period during which the Expanded Technical Assistance Program was established and developed, following the action of the



An FAO specialist in cotton production demonstrates a light ginning machine to his Ethiopian colleagues. Though not a supply agency, FAO does provide limited amounts of equipment and supplies as a part of its technical assistance work.

U.N. Economic and Social Council in 1949, under which this interorganizational program was established and under which work was initiated in July 1950. This new source of funds enabled FAO to extend direct advisory assistance to many of the less-developed countries. Activities included the sending of advisers, the provision of limited quantities of technical equipment and supplies, and the awarding of a substantial number of fellowships. Also, many regional training and development centers were held. This new and expanding phase of the Organization's program brought the underdeveloped countries a new source of outside assistance, and to the staff it brought new opportunities for field activities in support of the more "academic" types of work, activities that had been impossible up to that time except for limited opportunities for work in certain countries under the UNRRA-Transfer fund. Currently, the United States contributes 40 percent of the funds for the Expanded Technical Assistance Program, under legislation which provides for the matching of contributions of other countries on a 40:60 basis up to a specified amount.

The amount that FAO and each of the other agencies participating in the program receives each year is determined (within the total amount contributed voluntarily by governments that are members of all or any one of the organizations in the United Nations "family") primarily by the proportion of requests from governments for assistance that fall within its terms of reference. Other factors that affect the total amount are allotments for headquarters costs and for regional projects. The amounts available to FAO were $8,352,-451, or 24.70 percent of the total, in 1958 and approximately $8,225,390, or 24.67 percent of the total, in 1959.

Thus, by the end of its first decade, the FAO program had become more or less stabilized, with its regular and its Expanded Technical Assistance programs receiving approximately equal financial support. This situation persisted during the next three to four years.

A further major step in the development of FAO's program came with the establishment of the United Nations Special Fund, in October 1958. The first group of projects approved in 1959 for financing under this fund included five for which FAO became the executing agency. Later that year 12 more projects were assigned to FAO. For these 17 projects a total of $10,-185,600 was assigned to the Organization during 1959. In May 1960, 11 more projects, totaling $6,344,100, were allocated to FAO. These funds are assigned on a project basis and may be expended over several years; the period will vary according to the agreement covering each project, so it is difficult to estimate the additional resources that may be made available to FAO on a year-by-year basis. However, if a substantial proportion of the requested projects continue to be in FAO's field, FAO's annual resources from the special fund may compare favorably with, or even exceed, its resources from the regular budget or for the Expanded Technical Assistance Program. Thus, over the next few years, the FAO program may tend to become stabilized on a triple financial base, each of the three "legs" being more or less equal in terms of dollars. United States contributions to the special fund are currently 40 percent of the total, on the same 40:60 matching arrangement that applies to the Expanded Technical Assistance Program.

The Organization has also received some financial support from other sources. For example, the United Nations Children's Fund has financed a number of FAO agricultural and nutritional activities carried out in support of UNICEF-financed projects in various countries. The Council on Economic and Cultural Affairs (a private foundation) has supported some work in the farm-management field, relating to rice. A number of the less developed countries, not being able to secure all the outside assistance they needed from multilateral or bilateral sources and experiencing difficulties in recruiting staff members from outside their borders, turned funds over to FAO to enable that organization to recruit and administer staff members for service in their national programs. Currently, nongovernmental organizations, foundations, and member governments are being

A trainee in a training center for census-takers for Latin America, which was held in Peru under the combined auspices of FAO, the Inter-American Statistical Institute, and the United Nations, gets field experience in an experimental census.

Staff members of a school for dietitians at Pasaminggu, Indonesia, give a course for women of the community. The director of the school was the recipient of a fellowship for foreign study under the FAO technical assistance program.

asked to consider making voluntary contributions to a fund that will be used to support a freedom-from-hunger campaign, which the Conference authorized for the period 1960–65. This campaign is, in a sense, a rededication by member countries to the principles set forth in the FAO constitution when FAO was founded.

Success to Date

In the complex of world affairs, food and agriculture have important places. Improvements in transportation and communications are bringing peoples of all countries into closer and closer contact and are enhancing the understanding of peoples of each country regarding the situation in all the others. Thus, the wide gaps in food supplies and levels of living are becoming more apparent. Peoples of the less developed countries, becoming increasingly convinced that inadequate food supplies and poor living conditions are not inevitable, are seeking ways to better their lot. Developed countries, recognizing this need, have been extending economic and technical aid on an unprecedented scale.

The primary place of food and agriculture in world affairs was evidenced by the fact that, among the many international organizations created by governments after World War II, either as new agencies or replacements for old ones, FAO was the first to be set up.

Measuring the success, or lack of success, of an organization that deals with such a broad complex of problems is difficult indeed. Few objective yardsticks are at hand, but some subjective estimates may be useful.

Perhaps the greatest single contribution of FAO is the degree to which it has created understanding of the ways in which countries can work together to their mutual advantage. An example from the field of plant breeding will illustrate the point.

Between 1947 and 1958, FAO organized a series of ten meetings, in Europe and the Mediterranean area, on hybrid corn. These meetings enabled the leading corn breeders in this region to meet, to exchange information on their respective research programs, and to plan coordinated action. The Organization provided experimental seed from the United States and Canada during the first half of the period. Testing programs were planned at the meetings, and the results of the previous years' tests were reviewed to determine which hybrids could be used most advantageously in various countries and areas. The results were published, and made generally available to all countries, by FAO. As the work developed and as wider use was made of imported hybrid corn seed, attention gradually shifted to the development of inbred lines from breeding stocks available in the region in question and to the testing of hybrids from these inbred lines. The stimulus to plant-breeding work as a result of these activities was substantial. Also, marked increases in production resulted. For example, data submitted by the delegates to these meetings indicated that, in 1952, 6 percent of the corn area in 17 countries was planted to hybrids, and the increase in production resulting from the use of hybrids was estimated at about 400,000 tons. By 1954, the increase from the use of hybrids over the tonnage that would have been obtained through the use of ordinary open-pollinated varieties on the same land was estimated to be 640,000 tons. The value of this increase in 1954 was estimated to be $55 million. The amount spent by FAO to catalyze this activity, from the beginning of the work, in 1947, to 1954, had been only about $40,000.

Such striking results cannot be expected from all international efforts. But this work on hybrid corn does show what can be accomplished when an international organization provides competent scientific leadership and the forum in which representatives of countries can meet to tackle a common problem.

After the 1958 meeting it was decided that FAO leadership was no longer essential, and the corn-breeding activities have since been left entirely in the hands of the countries concerned. However, as a further step in making information available to all its member countries, FAO published a 440-page volume, *Hybrid Maize Breeding and Seed Production*. Like most other FAO publications, this was issued in the three official languages of the United Nations —English, French, and Spanish.

Similar activities have been undertaken in many other fields, Naturally, each activity develops along the lines required to meet the needs of countries in the respective fields. For example, one activity arising from the FAO International Rice Commission's work on rice breeding was a project to hybridize *japonica* and *indica* rices, with the aim of combining the high response to fertilizer of the *japonica* rices grown in more northerly latitudes with the capacity to adapt to tropical conditions that characterizes the *indica* varieties. In the Near East, an intercountry proj-

ect on wheat and barley breeding is actively under way; this has included cooperative efforts aimed at identification of rust- and bunt-resistant stocks suitable for use as parental material in national breeding programs. On the animal-breeding side, meetings have been held, in various parts of the world, devoted wholly or in part to the improvement of livestock through breeding. These have included, for example, a series of four meetings over the last ten years on livestock production in the Americas. These and other meetings gave much attention to the complicated genetic, physiological, and managerial problems of breeding livestock adapted to unfavorable environments. This line of work has resulted in a number of FAO publications other than the reports of the meetings themselves, including three major documents: "Breeding Livestock Adapted to Unfavorable Environments," "Zebu Cattle of India and Pakistan," and "Types and Breeds of African Cattle."

Although it is not possible to measure the effects of such activities precisely, it is clear that their catalytic action has resulted in much activity in the countries concerned and an increase in the flow of information between countries. When one makes a mental addition of these effects in all the technical fields covered by FAO, the impression of substantial results cannot be avoided.

Similar efforts have been made in other areas, such as credit, cooperatives, land tenure, commodities, statistics, economic analysis and planning, and the overall improvement of government services to agriculture, with emphasis on the organization of research, the organization and improvement of extension services, and the requirements and facilities for training agricultural scientists and leaders. Phillips, Moskovits, and Lininger have discussed the organization of agricultural research in Europe, and Chaparro has made an intensive study of higher education in the field of agriculture in Latin America. Activities in these several fields have also led to the exchange of much information and of many ideas among countries and have contributed substantially to the understanding by countries of each other's problems and of the areas in which coordinated action is desirable.

Without attempting to give further examples of the ways in which ideas proceed from member countries into the many forums provided by FAO, resulting in action in the countries concerned, with many interactions in the process, we may sum it up by saying that FAO has contributed much to an understanding of how countries can work together and, in addition, that the processes through which countries have gained this understanding have yielded many direct benefits in terms of information, ideas, and action.

The direct assistance which FAO has provided to individual countries in the underdeveloped areas should probably be ranked second among its achievements, although activities in this phase of FAO's program of work are admittedly more spectacular than those just discussed, and the results of direct assistance are difficult to compare with the less tangible results of intercountry discussions and coordination of ideas and actions.

Mention has already been made of the 1773 experts who had served in 40 countries up to September 1959, of the approximately 100 training and development centers which have been held, and of the projects already assigned to FAO under the recently established special fund. In addition, we should mention the missions which have made on-the-spot studies in various countries and the direct assistance by staff members and consultants, financed under the regular budget and by funds from several other sources.

Much has been done, for example, to assist countries in ridding themselves of the deadly cattle disease rinderpest. Veterinarians have assisted in the development of vaccines, the establishment of biologics laboratories and vaccine-production facilities, the training of field teams, and the organization of vaccination campaigns.

Governments of countries in the Near East and adjacent portions of Asia and Africa have been assisted in the organization and conduct of cooperative campaigns to control the desert locust. Recently they have been assisted in the initiation of an extensive cooperative research project aimed at making an ecological survey and conducting other studies to obtain more adequate knowledge of the locusts' breeding habits and breeding areas, of factors which affect reproduction, of methods of predicting

Workers in a cooperative project on the hybridization of *indica* and *japonica* rice at a rice research institute in Cuttack, Orissa, India.

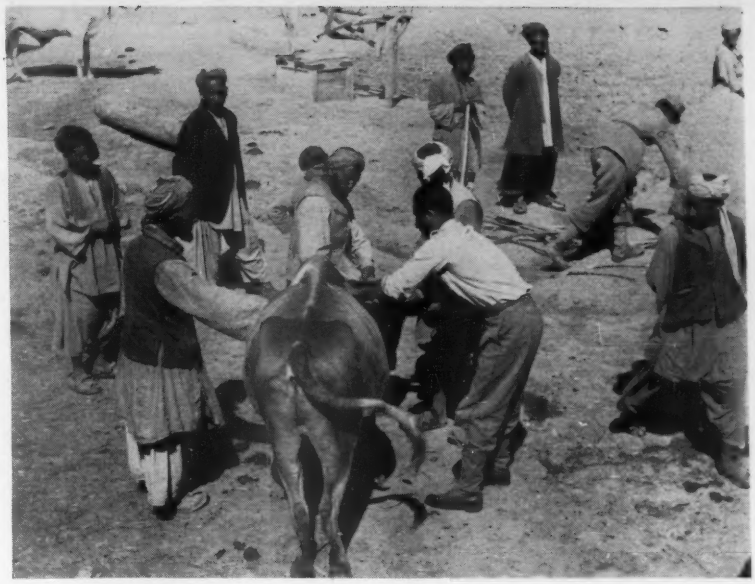
outbreaks, and of methods of control. Seventeen countries are involved in this effort.

Experts on soils and land use have helped or are helping many countries in the making of soil surveys, in soil fertility studies, and in planning for the most effective use of lands now cultivated or being brought under cultivation in new irrigation and other land-development schemes.

Nutritionists are assisting in the making of dietary surveys, determining how the nutritional needs of countries may be met more effectively, and in the development of new sources of foods rich in protein, minerals, and vitamins. Fisheries experts work with many governments in studies of both fresh- and salt-water fisheries, in an effort to develop more adequate sources of protein.

This listing of kinds of direct assistance could go on, covering all the technical and economic areas with which FAO deals. But these few examples, coupled with the indications already given of the over-all size of the effort, should be adequate to indicate that much is being accomplished to assist countries in their efforts to bridge the gap between modern agricultural methods and the practices followed in agricultural production, processing, and distribution and in food utilization.

A third major area to which FAO has contributed is that of the collection and dissemination of information. Much of FAO's publishing activity is an integral part of other phases of the program. Yet, the complex of statistical, economic, technical, and scientific information which FAO makes available to its member countries is a contribution which deserves recognition in its own right. A few titles, in addition to those mentioned above, will illustrate the variety and scope of FAO's publications: "Efficient Use of Fertilizers," "Water Lifting Devices for Irrigation," "Legumes in Agriculture," "Olive Oil Processing in Rural Mills," "Advances in Cheese Technology," "Meat Hygiene," "Marketing Fruit and Vegetables," "Protein Requirements," "Teaching Better Nutrition," "Agricultural Credit in Economically Underdeveloped Countries," and "Fact-Finding with Rural People." Such materials, while particularly useful to underdeveloped countries which may not have the facilities to compile the information for themselves, are also very useful to all the member countries of FAO (*1*).



A native worker, trained by an FAO veterinary adviser, vaccinates cattle against rinderpest in Afghanistan.

In the evaluation of an organization's work, it is easy to err on the side either of optimism or of adverse criticism. The Food and Agriculture Organization has had its share of failures, and of successes varying all the way from programs which just missed being failures to glowing successes. On the whole, its record has been good, and the member governments generally regard it as an organization in which they can participate with confidence and to which they can look for sound information and—particularly in the case of the underdeveloped countries—useful assistance.

What of the Future?

Against a background of useful service to its member countries, what are the prospects for the future?

Agricultural development, usually slow, is a continuing process. Just how soon the many underdeveloped countries will achieve "economic breakthroughs" and reach a stage which some are now calling "self-sustaining growth" is difficult to predict. But it seems certain that the process will go on for many decades. So the opportunities for direct assistance to governments from FAO will persist. The degree to which governments will use this channel in the future remains to be seen.

As populations expand (the population explosion threatens to bring the world total to six billion or more by the turn of the century), as contacts between countries become closer, through travel, better communications, and greater emphasis on trade, and as pressures on the land increase, the need for intercountry consultation and cooperation will certainly increase. The facilities of FAO and the experience gained to date in FAO forums should serve countries well. Nevertheless, it is difficult to predict how far governments will go in utilizing the channel of FAO in preference to others available to them.

The need for a ready international source of information—scientific, technical, economic, and statistical—seems certain to increase as relations among countries grow more intimate and complex, and as the world's store of information expands rapidly, reaching levels in many fields where the human brain—or the compiling facilities, in many countries—cannot cope with it all. Here, too, member governments will need to look carefully at the problem and to determine the kinds of compilation they need most from a central source such as FAO. Great wisdom will be needed in choosing the things to be done by FAO, in eliminating duplication of effort between FAO and governments of the member countries, and in selecting those areas wherein each government should depend upon its own resources.

Food made with fish flour, developed with the assistance of FAO representatives in a nutrition laboratory in Rangoon, Burma, is served in a nursery school.

The countries of the world are becoming increasingly interdependent, and although this fact is generally recognized, governments are under increasing pressures to make decisions regarding the development and utilization of their resources without adequate knowledge of the policies and objectives of other countries or often of the basic scientific, technical, and economic facts upon which the decisions should be based. On the other hand, governments have set up a substantial number of international and regional organizations, both technical and economic, to serve them. This has created a problem of coordination of another kind. There is much talk of coordination among agencies, and progress is being made. But the fields are many and the problems complex. One sometimes gets the impression that a stage has now been reached comparable to the warming-up, tuning-up stage in a large orchestra, when only a jumble of sound emerges. This is not an adverse criticism—rather, it is a reflection on the increasingly complicated world in which we live. The best of statesmanship will be needed in governments, and in FAO and other international forums, if this much-discussed coordination is to be achieved, and not allowed to become an end in itself.

Mention was made above of the extent to which FAO draws its finances from outside sources, in particular from the Expanded Technical Assistance Program and the United Nations Special Fund—sources over which the FAO governing body, the Conference, has no direct control. Here is a coordination problem of yet another kind. How does an organization plan and coordinate its own activities and ensure the effective use of its staff if its governing body controls only a rather small portion of its finances? The time is approaching when the proportion of FAO resources controlled by the Conference may be only about one-third or even less. Here, too, is a problem that will require real statesmanship in international agricultural and related affairs.

The degree to which FAO becomes an increasingly important source of information for governments and an instrument through which governments consult with one another and through which assistance is channeled to underdeveloped countries will depend primarily on the degree to which governments elect to use FAO for these purposes.

If governments do elect to deal with agricultural matters to an increasing degree through FAO, then perhaps the most important factors in determining the success of such intercountry efforts will be the following.

1) The competence of the representatives designated by governments to represent them in scientific, technical, economic, and policy-making forums.

2) The ability of the leadership of FAO to sense the real needs of the countries concerned and to build well-balanced programs aimed at meeting those needs.

3) The maintenance of a proper balance between the responsibilities and functions of governments on the one hand and of FAO on the other. One example of a particularly sensitive area is that of short- and long-range planning. Here, an international organization can be very helpful when it assists governments singly and, on occasion, in groups to improve the effectiveness of their planning operations, but it can generate suspicion and ill will if it attempts to do the planning itself.

4) The competence of the staff. An international organization requires staff members of a competence which commands respect among their counterparts in governments, members who have the imagination to develop programs that are of real benefit to the countries concerned, and who have the ability to deal with people from a wide variety of national backgrounds. The director-general, elected by governments to represent them in the management of the Organization, must depend to a large extent upon his staff, in both program building and implementation, so the success of his leadership depends to a large degree on the competence of those who serve under him.

Conclusion

The time has passed when ministries and departments of foreign affairs can carry the full load of foreign relations for their countries. In the broad field of food and agriculture, agricultural scientists and economists are playing an increasingly important role in international affairs. This does not mean that foreign ministries have a lesser role. On the contrary, as problems on the foreign-affairs front grow more complex, the size of the task increases. Already, it has increased to a point where support is needed on many fronts, including the various aspects of food and agriculture. This is a theme which Kistiakowsky stressed in his recent article on "Science and foreign affairs." If this trend continues, as seems almost certain, there will be a corresponding increase in the need for countries to "tool up" the mechanisms which are required if they are to work together more effectively on problems of food and agriculture.

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Note

1. The sales agent for FAO publications in the United States is the International Documents Service, Columbia University Press, 2960 Broadway, New York 27, N.Y.

Science in the News

Nixon on Education: His Policy Paper Endorses a Broad, Expensive Program of Federal Support

The new policy paper issued this week by the Vice President was entitled "A National Program of Support of Education," and the broad and expensive program it espoused carried Nixon well beyond anything the President or the Republican Congressional delegations have been willing to support in the past. Indeed, Nixon's public position becomes very close to Kennedy's, the principal difference being that Kennedy is more explicit about the size of the programs he has in mind and about how much he would like to spend.

Nixon proposed increased federal financial support to virtually every phase of the nation's educational system, from elementary schools to adult education. The paper specifically advocates a loan program for colleges that Eisenhower vetoed, asks for a federal scholarship program, a much expanded student loan program, and a program of grants to private and state universities to help finance expansion of facilities. It is a significant document, whether Nixon wins the election or not, for it places the leading Republican in the camp of the dominant wing of the Democratic Party in accepting a basic role for the federal government in support of the nation's educational system.

With few important exceptions, it has been customary to justify federal money for education on the grounds that an emergency program was needed to meet a specific critical situation. Federal aid to school construction, to the extent that it has been accepted at all by conservative Republicans and Southern Democrats, has been justified as an emergency measure to meet the critical classroom shortage; the federal student loan and graduate fellowship programs were justified as emergency programs to meet a threatening critical shortage of scientists (hence the title: National Defense Education Act); aid to federally impacted school districts was justified as a measure to aid districts in which a great deal of untaxable property (an air base, for instance) placed an unsupportable burden on the community.

To a great extent the "emergency" justification of many programs has been merely a convenient fiction to enable legislators to vote for federal action without too obviously compromising their adherence to the principle that education is a state and local, rather than a national problem. But the Nixon paper makes a complete break with this approach. Nixon's recommendations for aid to public school construction are justified only secondarily as a means of alleviating the temporary classroom shortage. The primary objective, Nixon says, is to indirectly make money available to raise teachers' salaries. Under a section headed "Loans, scholarships and fellowships" Nixon says: "A start, and a good one, has been made under the National Defense Education Act. . . . But this was in a sense 'emergency' legislation. We should now extend and expand this program." "All that we are and all that we hope to be," says the paper, "depend not only on the wisdom but also the sense of urgency with which we develop and mobilize and apply our total brainpower. . . . The target of American education must be that every individual has the opportunity and the facilities to develop to the highest power the full range of his inherent ability. There must be no arbitrary barriers—neither racial nor economic." The federal government, the paper makes clear, has a major share of the responsibility for seeing that this target is approached.

Public Schools

Under the program Nixon endorses, the essential line between the Republican and Democratic approaches to federal aid to public schools is reduced from a basic difference in attitude to a fine point in legislative technique. Kennedy and the Democrats have been advocating a program of about a billion dollars a year of federal assistance to public schools, with the states and localities free to use the money not only for classroom con-

struction but for textbooks, equipment, and teachers' salaries. Eisenhower made it clear that he would veto any such bill if it ever reached him. The Administration reluctantly endorsed a $350 million program limited strictly to construction funds to meet the classroom shortage. Taking the same view, the Republican platform specifically rules out federal aid to teacher salaries.

Nixon pays lip service to this approach by limiting aid to grants to pay for construction but in effect joins the Democrats in support of federal aid to salaries. The Nixon paper, for example, advocates federal grants to pay for servicing debts incurred by past construction. This is in addition to grants to pay for future construction, and its stated purpose is to allow the school districts to spend money on teacher salaries that would otherwise have to be earmarked for debt-servicing.

The justification for this roundabout approach, according to a spokesman for Nixon, is that by limiting direct federal aid to construction funds the temptation of Congressional committees to attach riders to the appropriation bills will be less than if the money were granted directly to the schools' operating budgets. The spokesman gave as an example the rider attached to the National Defense Education Act providing that none of the money could be used to buy scientific equipment from Iron Curtain countries. The rider was opposed by the State Department on foreign policy grounds, by the Commerce Department on international trade grounds, and by the Health, Education, and Welfare Department on the grounds that it was unwarranted interference in the affairs of the schools receiving the money. The rider nevertheless was attached to the bill and almost certainly will remain there as long as the bill is in effect.

But whether limiting federal aid to construction rather than operating budgets would actually lessen the temptation to attach such riders is not only somewhat debatable but a comparatively fine point. If this indirect system of aid to teacher salaries proved unworkable after a trial (if, for example, it were found that some school districts were using the federal grants simply to reduce local taxes rather than to increase teachers' salaries) it would be only a small step to move to a direct program of aid to teacher salaries. In effect Nixon has moved as close to the Democratic position on this issue as it is politically possible for him to do without plainly offending a great many of his supporters, including Dwight Eisenhower.

Colleges and Universities

At the college level Nixon advocates "as a top priority target" federal scholarships of up to $1000 a year "based on need and competitive examinations . . . . for our ablest secondary school graduates." He calls for an expansion of the student loan program. He says Congress should consider making college tuition tax-deductible, although he avoids flatly advocating this.

Kennedy opposes this step on the grounds that the government is going to need all the revenue it can get in the years ahead. The Democrats have been advocating cutting tax concessions generally as a means of minimizing the need for outright tax increases. It is a politically touchy target and would be just so much more difficult to achieve if the Administration were to advocate new concessions to some taxpayers at the same time it was advocating the elimination of well-established concessions to others. These considerations presumably account for Nixon's only lukewarm endorsement of this popular idea.

In the area of federal aid to colleges Nixon not only endorses a loan program which has been opposed by Eisenhower but goes on to advocate a program of grants as well. At the beginning of the year the President recommended that the current program of loans to colleges for building dormitories be dropped. Congress nevertheless passed a bill making an additional $500 million available for these low-interest loans. The President signed the bill rather than give the Democrats a campaign issue. Nixon not only endorses the dormitory loans but asks that the program be extended to cover loans for classrooms and other buildings. A year ago Eisenhower cited as one reason for vetoing a Democratic housing bill the fact that it included just such a program for loans for college classrooms.

In other areas Nixon proposed a variety of grants and loan programs for strengthening the teaching process, for offering financial assistance to teachers and to students preparing for teaching careers, for expanding medical educational facilities, and an expansion of existing programs for vocational training, education of the handicapped, libraries, and adult education.

Summing up, Nixon said that the program outlined showed "the elements of a broad program of federal encouragement to American education. I do not claim that it is exhaustive or that each element in it must be adopted in one precise form—that nothing more or less will do. Clearly, it will be the job for the executive and the Congress to work out the details, to estimate costs, and to make precise outlays for the period of testing ahead." Nixon said that the federal government could not be expected to solve all the problems, that its funds are not limitless. But the federal government, said Nixon, "must fulfill its traditional role of calling the nation's total resources, in all their local and private centers of authority, to effective action. We have no time to lose."

Republican Platform

In contrast to Nixon's position, the Republican platform, even after being strengthened at Nixon's insistence, is very cautious on the role of the federal government in education. It says: "the federal government should assist selectively in strengthening education." It endorses federal aid to school construction and pledges the continued support and in some cases extension of a number of programs already in effect. But later on the platform takes note again of the "temporary" and "declining" shortage of construction funds. "We believe," the platform says, "that any large plan of federal aid to education, such as direct contributions to or grants for teachers' salaries can only lead ultimately to federal domination and control of our schools, to which we are unalterably opposed." The Nixon program is a large program. Speaking for the Vice-President, Arthur Flemming, Secretary of Health, Education and Welfare, who was principally responsible for putting the program together, told the press that it was about as big a program as anyone could realistically expect to push through Congress.

Meanwhile the issue of teachers' salaries received delicate handling by Nixon during the debate Monday night. He opposed putting teachers on the federal payroll because of the danger of federal control. But no one is advocating putting teachers on the federal payroll. The Democrats say they want to make money available to the states, which the states can then use for teachers' salaries if they choose to do so. Nixon, as both the paper and other re-

marks during the debate made clear, would like to do the same thing, except in a more roundabout way. But Nixon's somewhat evasive handling of this issue was unavoidable. Just as Kennedy was evasive when it was suggested that his program would require tax increases, since no one runs for office on a pledge to raise taxes, so Nixon, as the Republican candidate, could hardly run for office on a commitment to move the federal government into an area where the conventional wisdom, to use Galbraith's phrase, insists that the federal government must not intrude. In fact, the proposals of either candidate, if carried out, would involve a certain amount of federal guidance, if not federal control, of education. But this is something the public is not yet ready to hear and that candidates for office are therefore not yet ready to talk about.—H.M.

News Notes

Committees Named for AAAS-Westinghouse Awards

Nine representatives from the fields of journalism, science, and education have been named to select the winners of the 1960 AAAS-Westinghouse Science Writing Awards. The nine, who will compose the screening and judging committees, will select the best science writing, exclusive of that in medicine, to appear in the nation's newspapers and general magazines during the current contest year. The writer of the best science story in each of the two types of publications will be awarded $1000. The awards will be presented at the annual meeting of the AAAS in New York in December.

The judges are Earl English, dean of the school of journalism at the University of Missouri; Alfred Friendly, managing editor of the Washington *Post and Times Herald;* George Gallup, director of the American Institute of Public Opinion; Morris Meister, president of Bronx Community College; Gerard Piel, publisher of *Scientific American;* and Alan T. Waterman, director of the National Science Foundation.

The screening committee has the following members: Hillier Kriegbaum, department of journalism, New York University; Sidney Negus, department of biochemistry, Medical College of Virginia; and James Stokley, school of journalism, Michigan State University.

The AAAS-Westinghouse Science Writing Awards were established to give recognition and encouragement to outstanding science writing, to stimulate public interest in science, and to foster a deeper understanding of the significance of science by the general public. The AAAS, the National Association of Science Writers, and Westinghouse cooperated in setting up the awards, which are supported by a grant from the Westinghouse Educational Foundation.

Entries in the newspaper competition must have been published between 1 October 1959 and 30 September 1960; in the magazine competition, entries must have appeared in editions dated between October 1959 and September 1960, inclusive. To be eligible, all entries must be posted before midnight *10 October 1960* and must have been published in a newspaper or magazine within the United States.

Inquiries about the competition and requests for entry blanks by entrants or their editors should be addressed to: Graham DuShane, Administrator, AAAS-Westinghouse Science Writing Awards, 1515 Massachusetts Ave., NW, Washington 5, D.C.

Nuclear Blasting Plan for Alaska Protested by Wilderness Society

The Atomic Energy Commission's plans to use nuclear explosions to blast a harbor in Alaska led the council of the Wilderness Society, at its recent annual meeting at Pine Creek Camp near Salmon, Idaho, to adopt the following protest resolution:

"*Project Chariot* is an attempt by the Atomic Energy Commission experimentally to blast a harbor at Cape Thompson in Alaska by nuclear detonations of one 200-kiloton bomb and four 20-kiloton bombs. The bomb which destroyed Hiroshima was one of these smaller bombs. Although studies are being made of wildlife in the region, including the neighboring sea, there is inadequate evidence of the effect of such detonations on wildlife. It is unquestionable that such detonations would unalterably destroy the wilderness area of the westerly end of the Brooks Range, our last great wilderness area in the world not in a tropical region. It would destroy the habitat of a large number of land and marine species and the nesting areas of numerous species of birds.

"Not only might the Eskimos in the region be affected by the damage to the land and the living things on which they depend for their sustenance, but the danger of radiation, small as it seems to be by comparison to above-ground detonations, might affect people over far greater areas. Furthermore, the blasting of a harbor on the Bering Sea is a threat to marine life at all ocean depths and over a great expanse. There is no limitation to the mobility of oceans."

Government's Environmental Health Programs Reorganized

Four new divisions have been established in the Public Health Service's Bureau of State Services in a reorganization move designed to strengthen environmental health programs and to improve the administration of various other programs.

Air pollution work, formerly divided into medical and engineering units, will be handled by a Division of Air Pollution. Vernon G. MacKenzie, a career engineer officer of the Service who has been engaged in air pollution control for the past 10 years, is chief of the new division. Richard A. Prindle, a physician who has specialized in the health aspects of air pollution and has been chief of the Service's air pollution medical program for the last 2 years, is the deputy chief.

Occupational health activities are being concentrated in a new Division of Occupational Health, headed by Harold J. Magnuson, who has been directing the PHS's occupational health program for the past 4 years. By raising the program to division status, it will be possible to increase the funds and manpower devoted to research on new chemicals and other industrial products and to develop better safeguards for the workers who process them. Since many health problems in the work environment are similar to those in the general environment, this division will also contribute to the effort to protect the public from new types of environmental health hazards.

A Division of Nursing, with Margaret Arnstein, a career nurse officer as chief, merges two former divisions: the Division of Public Health Nursing, which operated as a part of the Bureau of State Services, and the Division of Nursing Resources, which operated as a part of the Bureau of Medical Resources.

A Division of Dental Public Health and Resources, under the leadership of Donald J. Galagan, a career dental officer, merges the former State Services Division of Dental Public Health and the former Medical Service's Division of Dental Resources. All four new divisions began operation on 1 September.

U.S. Offers to Place Four Reactors under IAEA Safeguards

The United States has offered to place four of its reactor facilities under the provisionally approved safeguards system of the International Atomic Energy Agency. John A. McCone, head of the United States delegation and chairman of the United States Atomic Energy Commission, made the offer at the fourth general conference of the agency in Vienna, Austria, which opened its 2-week session on 20 September. The four reactors are the Brookhaven Graphite Research Reactor at Brookhaven National Laboratory, Upton, N.Y.; the Medical Research Reactor at Brookhaven; the Experimental Boiling Water Reactor at Argonne National Laboratory, Argonne, Ill.; and the Piqua Organic Cooled and Moderated Power Reactor, Piqua, Ohio.

The United States offer was made to demonstrate the workability of agency safeguards and would provide, in effect, a field laboratory in which safeguards inspection methods and techniques would be tested and improved. The IAEA safeguards system has been developed to assure that nuclear assistance made available through the agency is not used to further any military purpose. The system was provisionally approved by the agency's board of governors in April.

News Briefs

Soviet metabolic research. A team of five American scientists arrived in Moscow on 26 September for an 18-day survey of the progress of metabolic disease research in the Soviet Union. The mission is sponsored by the National Institute of Arthritis and Metabolic Diseases of the U.S. Public Health Service. It is part of the scientific-cultural exchange program under the 1958 Lacy-Zaroubin Agreement between the United States and the Soviet Union. Under the program Soviet scientists visited U.S. laboratories last February. The group in the U.S.S.R. includes Floyd S. Daft, William H. Sebrell, Jr., J. Murray Luck, Currier McEwen, and Clifford J. Barborka.

* * *

Biological Abstracts. Biological Abstracts will dedicate its newly renovated headquarters building in Philadelphia with a symposium, 6–7 October, on problems and trends in scientific communications. The organization publishes abstracts of biological publications from countries all over the world, including those behind the iron and bamboo curtains. Leading biologists who will attend the dedication ceremonies and participate in the symposium include: Biological Abstracts director G. Miles Conrad, Foster E. Mohrhardt, John J. O'Connor, William C. Steere, Wallace O. Fenn, Sidney Weinhouse, Milan J. Kopac, Conway Zirkle, John S. Nicholas, Lloyd W. Hazleton, Paul B. Sears, and James G. Horsfall.

* * *

U.S. population. This summer the Census Bureau estimated the present population of the United States to be approximately 179,500,000, an increase of 28 millions (18.5 percent) since 1950, the largest gain for any decade in American history. Alaska, with an increase of 74 percent—from 128,643 in 1950 to 223,888 in 1960—is outstripping all other states in percentage of population increase.

* * *

Education and civil defense. The American Council on Education has announced the appointment of a committee to prepare a special report concerning higher education and civil defense. Thomas H. Hamilton, president of the State University of New York, is chairman. Operating under a contract with the Office of Civil and Defense Mobilization, the committee will bring up to date the council's 1954 publication, *Civil Defense and Higher Education.* The first meeting of the new committee will be held in November at OCDM headquarters, Battle Creek, Mich.

* * *

Polio control. The Public Health Service has announced the formation of a Surgeon General's Committee on Poliomyelitis Control to be made up of representatives of the medical and health professions and the general public. The heads of 23 organizations are being asked to designate members to serve on the committee, which will consider integrating a live poliomyelitis vaccine pro-

The west face of the Brookhaven Graphite Research Reactor at the Brookhaven National Laboratory. On the first balcony, physicists and chemists are measuring the energy from beams emerging from the reactor, while on the ground floor and on the second balcony, health physicists are monitoring the ports to check for possible radiation leaks. This reactor is one of the four which the United States has offered to place under the proposed safeguards system of the International Atomic Energy Agency. The Brookhaven National Laboratory is one of the Atomic Energy Commission's principal research facilities.

gram with the current Salk vaccine program.

The use of live virus vaccine in the American population poses a number of special problems. It has been suggested that the administration of the live virus vaccine will be more appropriate on a community than on an individual basis, some experts having expressed fear that the vaccine might revert to virulency after many trips through the human intestines unless large groups established immunity simultaneously. All trials of the vaccine so far have been on a mass inoculation basis.

* * *

Spectrum of Jupiter. An analysis of spectrograms of the planet Jupiter has recently been completed at the National Bureau of Standards. For the first time detailed wavelength measurements have been made of the lines in various absorption bands of methane and ammonia. In the infrared region, four lines of the quadrupole rotation-vibration spectrum of the hydrogen molecule were found, confirming the presence of hydrogen in Jupiter's atmosphere. In the violet and ultraviolet regions, a continuous absorption was recorded that closely resembles that of the nitrogen tetroxide molecule. Another investigation is planned in which equipment especially appropriate to the study of the far ultraviolet region will be used.

* * *

Scientists in the Congress. Only 15 members, or less than 3 percent, of the U.S. Senate and House of Representatives have had any extensive scientific training or background, whereas more than 25 percent of the deputies of the Supreme Council of the Soviet Union are scientists, according to a recent survey conducted by Science Service.

* * *

Primer on water. The U.S. Department of the Interior's Geological Survey has issued a nontechnical pamphlet, *A Primer on Water*, written in two parts. Part 1 covers the science of hydrology, and part 2 is concerned with the magnitude and use of the total supply of water in the United States.

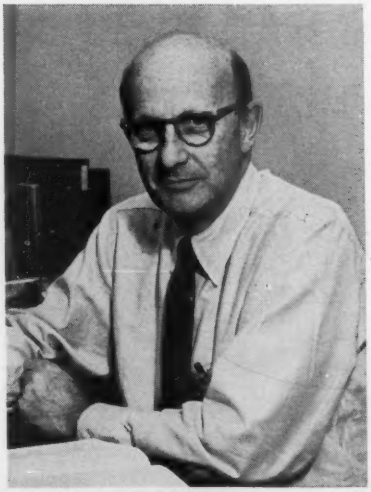
The pamphlet notes that the country as a whole receives an average of about 30 inches of precipitation each year; that almost three-fourths of this amount is returned to the atmosphere by evaporation and transpiration; and that the remaining one-fourth contributes to runoff and ground storage and constitutes the water available for withdrawal. This means that the available 25 percent amounts to an average yield of some 1,300,000,000 gallons per day, or 7500 gallons daily for every man, woman, and child in the country. The primer may be purchased for 35 cents from the Superintendent or Documents, Government Printing Office, Washington 25, D.C.

Scientists in the News

Lewis R. Koller, physicist, retired recently after 34 years with the General Electric Research Laboratory in Schenectady, N.Y. He has joined the staff of the National Research Corporation, Cambridge, Mass.

Koller joined General Electric in 1922 as a physicist at the Edison Lamp Works, a year after receiving his Ph.D. degree from Cornell University. He shifted to the Research Laboratory in 1926, where he worked with the late Saul Dushman in pioneering studies of vacuum techniques and electron emission.

He has made important contributions in such diverse fields as electron-tube technology and medical sterilization. His studies of oxide-coated cathodes have contributed to the former field, and his work on the germicidal effect of ultraviolet radiation has advanced the latter. Koller is also well known for his work in photoelectricity, especially the use of cesium in photoelectric cells; cathode luminescence (the effect that produces light on a television screen); and electronic properties of very thin films. His writings include two books, *The Physics of Electron Tubes* and *Ultraviolet Radiation*.



Lewis R. Koller

Recent appointments to the staff of the U.S. Bureau of Commercial Fisheries' Honolulu Biological Laboratory include appointment of **Lucian M. Sprague** as chief of Sub-population Investigations and **Wilvan G. Van Campen** as head of Scientific Services. Sprague will study the identity and distribution of blood-group systems in fishes, particularly tunas, and the genetics of fishes in general. Van Campen will serve as scientific editor for the laboratory.

Two American scientists recently received honorary degrees from the Technical University of Norway at Trondheim during a program celebrating the university's 50th anniversary—**Olaf A. Hougen**, professor of chemical engineering at the University of Wisconsin's College of Engineering, and Lars Onsager, professor of physical chemistry at Harvard University.

S. S. Stevens, professor of psychology at Harvard University, has received the $1000 Distinguished Scientific Contribution Award of the American Psychological Association. He was cited for his work in the "new psychophysics," in which sensations such as loudness and brightness have been shown to increase as power functions of stimulus magnitude.

World Health Organization director-general M. G. Candau has announced the appointment of **Fred Grundy**, Mansel Talbot professor of preventive medicine at the Welsh National School of Medicine, Cardiff, Wales, as a new and fourth assistant director-general of the organization. Grundy will officially take up his new duties in 1961 but will attend WHO's executive board meeting in October.

Robert J. Schnitzer, formerly head of the chemotherapy department of Hoffmann-La Roche Inc., Nutley, N.J., has joined the scientific staff of Academic Press, New York.

Merle M. Andrew, director of mathematical sciences at the Air Force Office of Scientific Research, has received a cash award and citation for his "sustained superior performance of duty" during the past fiscal year. He was honored for his establishment of an outstanding program of mathematical research, in which some of the most eminent mathematicians in the United States and other countries participated.

The State University of New York's Downstate Medical Center, Brooklyn, has announced the appointment of **Ludwig W. Eichna**, formerly professor of medicine at New York University College of Medicine, as professor and chairman of the department of medicine and of **I. Charles Kaufman**, formerly associate professor of psychiatry at Boston University School of Medicine, as professor and chairman of the department of psychiatry.

Eichna succeeds **Perrin H. Long**, who has retired from the chairmanship but who will remain on the faculty as professor of medicine. Kaufman succeeds **Howard W. Potter**, who retired as professor and chairman in 1957 and whose post has been filled for the past 3 years by **David Engelhardt**, associate professor of psychiatry, as acting chairman. Engelhardt will remain on the faculty as associate professor of psychiatry.

Sidney Mittler, formerly research biologist at the Armour Research Foundation of Illinois Institute of Technology, is now a professor in the department of biological sciences, Northern Illinois University, De Kalb.

Hermann H. Kurzweg, professor in the department of aeronautical engineering at the University of Maryland and a member of the graduate faculty there, has been named assistant director for Aerodynamics and Flight Mechanics in the National Aeronautics and Space Administration's Office of Advanced Research Programs. He succeeds **Milton B. Ames, Jr.**, who was recently appointed deputy to Advanced Research Programs director **Ira H. Abbott**.

The American Institute of Biological Sciences has announced the establishment of two new positions on the senior staff: **John R. Olive**, for the past year assistant executive director, has been named deputy executive director, and **Howard F. Campbell**, comptroller, has been appointed administrative officer.

Louis K. Diamond of the department of pediatrics, Harvard Medical School, and Children's Hospital Medical Center, Boston, has left for a 4-month trip to the Near East, Central Africa, and Latin America, under a travel grant from the Rockefeller Foundation. He is making a survey of the incidence, types, and severity of anemias in children with kwashiorkor, or nutritional failure. He will also lecture on pediatrics in various cities.

Michael Laskowski

Michael Laskowski, professor of biochemistry at the Marquette University School of Medicine, has been awarded a $111,000 faculty grant by the American Cancer Society. The grant, which enables the university to create a position for the academic lifetime of an investigator, is the 13th such award made by the American Cancer Society. The special program was established to support investigators of extraordinary promise in the fields of medical, biological, and related physical sciences. Laskowski is an enzyme chemist who has worked primarily with catalysts which split nucleic acids and proteins.

Also at Marquette, **Adolf L. Kappus**, professor and chairman of the department of microbiology and immunology, has been appointed a consultant for the International Cooperation Administration in El Salvador, effective 1 October. He is in San Salvador, where he is serving as an adviser to the University of El Salvador Medical School and the Ministry of Health and Social Assistance.

R. Ruggles Gates, anthropologist, formerly of Cambridge, Mass., is now living in London (46 Lincoln House, Basil St., Knightsbridge, London, S.W.3).

Recent Deaths

Martha Doan, Franklin, Ind.; 87; chemistry professor and dean of Women at Earlham College from 1915 to 1926, and at Iowa Wesleyan University from 1929 to 1937; translated Fritz Poneth's *Radio Elements as Indicators and Other Selected Topics in Inorganic Chemistry*; 15 Apr.

Ralph E. Dunbar, Fargo, N.D.; 65; dean of the School of Chemical Technology at North Dakota Agricultural College since 1945; 5 Sept.

Sir **Arthur P. M. Fleming**, London, England; 80; electrical engineer whose development of electronic techniques helped to make radar possible; was for many years with British Westinghouse, subsequently with the Metropolitan Vickers Electrical Company, first as insulation expert, then as transformer designer, and later as manager of research and education; served on many private and governmental educational advisory bodies; knighted for his services to education; 14 Sept.

Ernest W. Goodpasture, Nashville, Tenn.; 73; professor of pathology and former dean of the Vanderbilt University Medical School; his research in 1931, in which he used live chicken embryos to cultivate viruses for a mumps vaccine, paved the way for mass production of vaccine against typhus, influenza, smallpox, and yellow fever; from 1955 until his retirement last year, was scientific director, department of pathology, Armed Forces Institute of Pathology at the Walter Reed Army Medical Center in Washington; had been a director of the Institute of Nuclear Studies and a scientific director in the international health division of the Rockefeller Foundation; was a former president of the Association of Pathologists and Bacteriologists and of the Society of Experimental Pathologists and a former vice president of the AAAS; 20 Sept.

Brother **George Lewis**, Philadelphia, Pa.; 71; professor of mathematics and former dean and vice president at La Salle College; president of Scranton University 1925–31; 8 Sept.

Vincent J. McLaughlin, New York, N.Y.; 46; psychologist and educator; a member of the faculties of both Fordham and Hunter College as a lecturer in psychology and education; 17 Sept.

Julius Molnar, New York, N.Y.; 63; a pathologist and director of the Stuyvesant-Polyclinic Laboratory and the Molnar Laboratories; conducted research on cholesterol metabolism; 18 Sept.

Dorothy Waldo, Plainfield, N.J.; 75; an educator for 44 years whose last position was that of professor of educational psychology at Douglass College (women's college within Rutgers University), 1939–52; 19 Sept.

Book Reviews

A History of Metals. vol. 1 and vol. 2. Leslie Aitchison. Interscience, New York, 1960. xxi + xvii + 648 pp. Illus. $30.

These two large volumes, with 8½-by 11-inch pages, contain "a biography, not of men but of a family of substances" (page v, vol. 1). The author "first took industrial employment" in 1909 in a factory where an old-fashioned tilt-hammer "was functioning with complete satisfaction" (page 310), and he has seen and made contributions to many changes in the industry of metals. On the foundation of his own experience, Aitchison now describes the history of metals from the earliest times to the discovery of the transuranium elements. He narrates in a pleasingly readable style the complex cultural, political, economic, and technological aspects of metals in history.

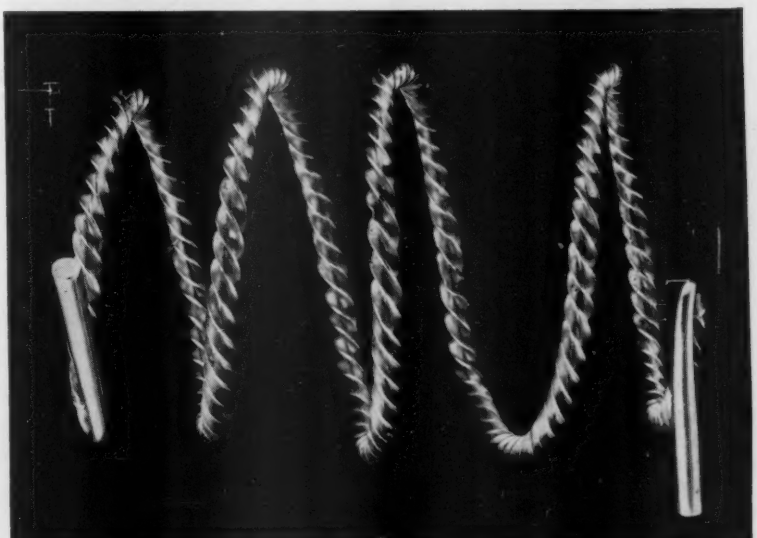
The impact of metals on cults and on cultures went so deep that ancient religions included such figures as the Egyptian Ptah (in the third millenium), the "master of the gold-smiths and gold-smelters," who had among his priests the "great wielder of the hammer" and one "who knows the secrets of the gold-smiths" (page 263); Hephaistos, "the lame god of the forge and smithy"; and the Roman god Vulcan. In many old legends, the smith was endowed with magic powers. Gold was used in religious art—for example, in the magnificent necklace from Ur (about 2600 B.C., frontispiece, vol. 1), and copper was used for the bull's head from Al 'Ubaid (2800 B.C., Fig. 6).

But Aitchison reminds us that metals were also used for making weapons. In the 5th century B.C. Herodotus deplored woeful applications of iron. The elder Pliny called iron "the best and worst servant of humanity" (page 1). More cheerful was the outlook of Bartolommeus Anglicus, the Franciscan friar who lived around 1250: "Without yron the comminaltie be not sure against enemies . . . no field is eared without Yron, neither tilling crafte used, no building builded without yron . . ." (page 345).

Political influences altered the rate and the course of developments. The disintegration of the Roman Empire threw metal businesses back to the stage they had attained about 1000 years earlier. The conquests in the New World were largely inspired by the hope of gaining precious metals. Large amounts of gold and silver from the new sources, estimated at the equivalent of almost $500 million, entered Europe by way of Spain; consequently, the purchasing power of these metals fell, so that "at the end of the sixteenth century Spanish prices had rocketed to about two and a quarter times the level for the years 1521 and 1525" (page 370). Henri Sainte-Claire Deville was encouraged in his search for a commercial production of aluminum by Napoleon, who hoped the new metal would provide lightweight armament.

Technologically, some of the main problems were to obtain high temperatures and power. As recently as 1632, Jordan obtained a patent for replacing wood fuel by coal, peat, and turf in certain smelting operations (page 432). The new system in chemistry and the great discoveries of elements in the 18th century brought many changes in the history of metals. A new "age of alloys" started about 1890 (page 583). And yet, the method of making hollow castings by the lost-wax process, which stems from "well before the middle of the third millenium" (page 197), is still "the most satisfactory method so far developed for fabricating engine components in some of these special alloys . . ." (page 602).

The historian trying to recreate the great story of the metals has to solve problems in organizing and selecting his materials. Aitchison has organized his story well, but his selections, especially for the latter part of his book, will scarcely find general approval. He could have shortened the rather well-known stories of atomic theory and of the periodic system of the elements to make room for an account of the chemical properties and uses of metals and their alloys. It is not adequate to the scope of this book to say of stainless steels only that "now everybody knows them in the forms of sink-units and kitchen equipment" (page 583). Besides, when Harry Brearley is mentioned as an inventor, it would be only just to name Strauss instead of, or together with, "Krupps at Essen."



Twisted gold torc from Grunty Fen (near Ely, Cambridgeshire, England), about 1600 to 1500 B.C. [Courtesy University Museum of Archaeology and Ethnology, Cambridge University, from *A History of Metals*].

Several annoying errors in chemical history could easily have been avoided. Basilius Valentinus is treated as a real person, although, even in this book, mystery surrounds him; he is supposed to have preceded Paracelsus by about a century (page 291) and yet to have survived to publish work in 1650 (page 482). The phlogiston theory is described as having been "exploded by Lavoisier and his English contemporaries" (page 294), of whom Priestley and Cavendish, those stout phlogistonians, are specifically named (page 476). It is not true that "during the first half of the eighteenth century, the halogen elements were discovered, as were also boric and phosphoric acids" (page 479).

There are a few more such minor blemishes, but instead of listing them here, the great value of this book should be emphasized. Its skillful and many-sided description of the history of metals is greatly enhanced by profuse illustration. This includes maps of the ancient world, clear outline drawings and pictures, 262 in all, placed right on, or very close to, the page on which their story is told. Some of them are dramatically confronted—for example, the iron-carbon equilibrium diagrams (Figs. 246 and 247); a sculpture by Rodin and the propeller for the liner R.M.S. Queen Elizabeth (Figs. 256 and 257).

In addition to references at the end of each of the 15 chapters, there are 6 pages listing "some sources." Studying all these references brings to mind Peter Guthrie Tait's remark in the introduction to his "Sketch of thermodynamics" (1877) about "the old absurd British contempt for all things foreign. . . ." Aitchison cites very few American books, only two German, and no French or other "foreign" publications. The old French works by Hassenfratz, the newer ones by Léon Guillet and Bertrand Gille, Sten Lindroth's Swedish book on Stora Kopparberg, and the many German ones—by Beck, Osann, Tammann, and others—do not appear in this bibliography. At least, John Webster's *Metallographia or an History of Mettals,* first published in London in 1661, should be listed in a second edition of Aitchison's work, and, in view of its great merit and beauty, a second edition should soon become necessary.

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Anthropological Papers. Numbers 57–62. Bulletin 173, Bureau of American Ethnology. Smithsonian Institution, Washington, D.C., 1960 (order from Supt. of Documents, GPO, Washington 25). iv + 498 pp. Illus. $3.25.

Bulletin 173 is a collection of six papers on specialized topics. Three papers (Nos. 57, 58, and 62) discuss restricted archeological manifestations in the United States. Paper 57, C. G. Holland's "Preceramic and ceramic cultural patterns in northwest Virginia," is an excellent example of the useful results obtained by pooling amateur and professional efforts: Holland, the amateur, contributed an intimate knowledge of the area and several years of careful collecting, and Clifford Evans and Betty Meggers of the Smithsonian Institution provided the systematic framework which makes the report a valuable first approximation of the cultural sequence in northwestern Virginia. Paper 58 is "An introduction to Plains Apache archeology—the Dismal River aspect," by James H. Gunnerson, who concludes that the group of sites, chiefly in western Nebraska, comprising the aspect represent the final phase (about A.D. 1700) of Apache domination of the High Plains. Gunnerson further suggests from archeological evidence that the southwestern Athabascans (Apache and Navaho) came to the southwest via the High Plains around A.D. 1525. The third archeological paper (No. 62) is "Stone tipi rings in north-central Montana and the adjacent portion of Alberta, Canada: their historical, ethnological, and archeological aspects," by Thomas F. Kehoe. Kehoe concludes that most of the circles of stones in the area (and probably elsewhere in the Plains) are in fact tipi cover weights, although this explanation will not serve for all types of configurations of stones. The remaining three papers are a miscellany including No. 59, "The use of the atlatl on Lake Patzcuaro, Michoacan," by M. W. Stirling; No. 60, "A Caroline Islands script," by Saul H. Riesenberg and Shigeru Kaneshiro; and No. 61, "Dakota winter counts as a source of Plains history," by James H. Howard. Stirling's paper describes one of the few survivals of the spear thrower, a device of Paleolithic antiquity. Howard describes nine hitherto unpublished "winter counts"—annual pictographic records of outstanding events drawn on hides or cloth—and comments on their consistency and chronological reliability. Riesenberg and Kaneshiro present an interesting study of cultural innovation—the development by stimulus diffusion of a syllabic system of writing derived from European writing through an American missionary and native intermediaries.

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The Physiology of Crustacea. vol. 1, *Metabolism and Growth*. Talbot H. Waterman, Ed. Academic Press, New York, 1960. xvii + 670 pp. Illus. $22.

This is a valuable book, comprising 17 reviews of aspects of crustacean physiology by a well-chosen group of authors and coauthors; the whole is well edited, unified, documented, and indexed. In its general level and approach it may be compared with *Insect Physiology*, edited by K. D. Roeder (Wiley, 1953), although the completed *Physiology of Crustacea* (two volumes are planned) is scheduled to have twice as many contributors as the earlier work.

Naturally, the treatment accorded the various topics in this first volume is as diverse as one might expect from its 18 contributors. The length of the chapters varies with the scope of the selected topics from as little as 12 pages in chapter 12 ("Ecology and metabolism," by Florkin) to 57 pages in chapter 2 ("Respiration," by Wolvekamp and Waterman), and the number of references per chapter also varies, from 56 to 257, averaging 109. Some idea of the extensiveness of the review coverage might be gained from the fact that the author and coauthor index includes 1208 names, many of which represent more than one paper. Since each chapter has its own bibliography (unlike the single bibliography of *Insect Physiology*), there is repetition of titles, and I did not attempt to determine the actual number of separate papers cited; as a guess, I would say over 1400.

One aspect of the excellent editing of this work is seen in the extensive indexes, which total 78 pages (about 12 percent of the book). There is an author index, indicating by page and superscript numerals each point at which an author is cited; in most instances authors are not cited by name in the text.

With the index, the curious researcher can easily check all citations of his own work without having to read the whole book. If, however, he does read the book, as he should, he will find the second or systematic index even more useful. The editor has followed the practice of referring to a given species by one specific name, that considered currently most valid (presumably by Chace), regardless of the names originally used by authors of cited works. Thus we note that *Homarus gammarus* is used without explanation throughout the text in referring to the European lobster, which has hitherto been generally called *H. vulgaris* in the published literature. In addition to giving synonyms in such instances, the index gives the family or higher group of all genera cited, as well as the older names *not* used in the text; all of this is most helpful to the reader, physiologist or other, who is not versed in crustacean systematics. There is a good subject index.

Among the chapters, each a self-contained review, which make up this volume, some are outstandingly good, others are valuable contributions, and one or two approach the pedestrian level or represent compilations of facts rather than fresh analyses of the topics. But all are competently and conscientiously done. Although a full review should discuss each chapter separately, space permits comments on only a few representative chapters.

Chapter 1 ("General crustacean biology," by Waterman and Chace) impresses me as being too general to be especially helpful. It includes an up-to-date outline of classification which, however, lacks characterizations of the intermediate groups and, hence, is of little use to the physiologist who might want to know what manner of beast a given taxon represents. Neither in text nor illustrations is it clear, for instance, why the much-discussed Cephalocarida rate the status of a subclass, nor is the selection of *Anaspides*, a form most physiologists have neither seen nor heard of, as a basic type likely to convey much information to the group that needs it most. Both authors understand crustacean systematics, and they talk *about* it intelligently; but most of their potential readers do not understand systematics, and probably never will unless given more illustrated basic material than this chapter provides.

In chapter 2, we find a good discussion of respiration. As the authors note (page 91), "The Crustacea do not seem to have any striking idiosyncrasies or innovations in their respiratory functions." Certainly this chapter analyzes the *general* aspects of respiration very well; it does, however, suffer from a lack of illustrations of the peculiarly *crustacean* respiratory organs, especially details of gills, the tracheal bodies of isopods, and other morphological features which would make this chapter more interesting and valuable to the physiologist seeking an introduction to crustaceans as physiological material. Certain other chapters are similarly lacking in illustrations. By contrast, chapter 5 ("Circulation and heart function," by Maynard) does provide helpful illustrations of the heart and circulatory arrangements in Crustacea, so that the stranger may feel better acquainted with the organization of these animals. In addition to his excellent organizational job, Maynard holds the record in the volume for number of references cited (257). Certain chapters deserve mention because they bring together material not previously presented in comprehensive and analyzed form. Chapter 13 ("Sex determination," by Charniaux-Cotton) is a well-illustrated section bringing together much information not hitherto treated in an English language publication. However, exception must be taken to this author's view that a "reversion toward unisexuality" has occurred in certain Cirripedia; the genera cited as examples include some that are probably primitive, and their unisexuality would seem to be primitive rather than derived from a hermaphroditic condition. Chapter 15 ("Molting and its control," by Passano) tends to over-compilation of facts in places, but salvages the situation with a good attempt at unification of arthropod molt-control mechanisms. Some other chapters are of equal quality, but do not happen to deal with material so much in need of review. The topic of parasitism is not specifically dealt with in any one chapter, except where secondary sources are cited.

The general level of editing is high; there are numerous cross references between chapters. Although there is diversity of opinion between authors, there is little superfluous overlapping of material, and there are few noticeable gaps in coverage. One discrepancy is in the use of the terms exo- and endocuticle in chapters 14 and 15; the index-reference, "Exocuticle, see under Cuticle, endocuticle," does not alleviate the situation. Also, I hope to learn by return mail from the authors the sources of the following undocumented statements concerning maxillary and antennal glands: (pages 5–6) "In mystacocarids, lophogastrid mysids and Nebaliacea both pairs of glands are present in adults," and (page 342) "Rarely, both pairs may be retained in the adult (Ostracoda and *Nebalia*)." However, such lapses are rare. There are very few typographical errors; I noted no more than half a dozen; the only one in which the meaning is altered is the use of "hyposmotic" for "hyperosmotic" in the last line of page 361.

At the time this volume appeared, the price of $22 seemed formidable; but it should be noted that there was a prepublication price of $19, and the professional discount provided a further reduction for some readers at least. Considering the general quality of the reviews included, the obvious care in editing, and the really large amount of information assembled and documented, I feel that this volume, and undoubtedly the one which is scheduled to follow it, will be indispensable to any biological library. No worker on the comparative physiology of invertebrates can afford to be without access to it.

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In the Company of Man. Twenty portraits by anthropologists. Joseph B. Casagrande, Ed. Harper, New York, 1960. xvi + 540 pp. Illus. $6.50.

If social anthropology differs from the other behavioral sciences, and if (despite its affiliation with the National Academy of Sciences and other scientific associations) it retains a strong humanistic flavor, surely one of the bases for these characteristics is its *informant* tradition. The ethnological informant is neither a psychological *subject* nor a sociological *respondent* (although he may, of course, be used in either or both of these capacities as well). The informant, *qua* informant, is a knowledgeable member of his society who serves the anthropologist as a primary source of information concerning its cultural traditions and social structure. He is the guide, the anthropologist is his follower; he the teacher, the anthropologist his student; he the superior, the anthropologist his inferior.

But the informant-anthropologist relationship is unique in scientific research for yet another reason. Since theirs is a long, an intimate, and a widely ranging encounter, it almost necessarily becomes a deeply personal, and not merely a research, relationship. As such, it is characterized by all the ambiguity and ambivalence inherent in any personal relationship, multiplied by whatever factor must be introduced because of the wide cultural and intellectual differences between anthropologist and informant, which serve both to attract and to repel. I know of no better way of introducing students and laymen alike to both the rewards and the problems entailed by and encountered in this relationship than to recommend this volume.

Casagrande has obtained the cooperation of an important cross-section of American and British anthropologists who, on the basis of their extensive field work, have produced, with two or three exceptions, a series of skillfully and, in some cases, beautifully written sketches recounting their relationships with informants in 20 widely scattered parts of the globe. The candor with which most of these contributors have approached their assignments will enable the methodologically oriented reader to assess both the strengths and the weaknesses of informant-type research. Because of its limitations, this research technique has long been, and will continue to be, supplemented by techniques borrowed from the other behavioral sciences. Because of its strengths, it will never be replaced.

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A Conscience in Conflict. The life of St. George Jackson Mivart. Jacob W. Gruber. Published for Temple University Publications by Columbia University Press, New York, 1960. x + 266 pp. Illus. $6.50.

When a professional biologist remembers St. George Mivart (1827–1900)—if he remembers him at all—it is apt to be with some irritation and more than a little contempt. Irritation because Mivart used his considerable talents to obscure and confuse the developing theory of evolution, and contempt because he was too bigoted and intellectually dishonest to follow where the scientific discoveries of the late 19th century led. That this picture of Mivart is inadequate and in great part unfair is amply shown by this clear, interesting and skillfully written biography.

Mivart was a man of great courage and tactlessness. While he was personally pleasant, he spared no one when he wrote. He was exceptionally —even painfully—conscientious, and he always followed the directives of his conscience. But he could never conceive of the fact that he himself could ever be wrong in anything. Inevitably his life was tragic.

At the age of 16, and in spite of his family's opposition, he became a convert to Roman Catholicism. This was no light step for him to take because, at the time, his conversion excluded him from Oxford and Cambridge. Later on he became a student of Huxley's and for a decade—during the 1860's—he and Huxley were very close, even intimate friends. Mivart became an expert osteologist and comparative anatomist, specializing in the Primates. He joined the Darwinian circle and was considered an important ally in the controversy that arose over evolution. Mivart, however, became dedicated to the discovery of absolute truth, but he based his "truth" on a double foundation—on Revelation and on Science. For him true Revelation and true Science could never be in conflict, because all Truth was self-consistent. Revelation, he was convinced, was in the custody of the Catholic Church, but the understanding of this Revelation could be enhanced by Science, that is, when Science is interpreted by Reason. Having these clews as to where Truth was to be found, he could tell exactly when Revelation was misinterpreted and when Science presumed to wander out of its proper sphere. Mivart devoted his life to promoting the fortunes of a liberal, growing, and changing Catholicism guided in its progress by an advancing Science. His failure in what he considered to be his real reason for living had the inevitability of Greek tragedy.

Relations between Mivart and the Darwin group became strained when the theory of evolution was extended to include the human species. Mivart believed that the mind and the soul of man could never have been developed from a brute origin, and he sought to limit the effectiveness of Darwinian evolution. He even went so far as to denounce natural selection as a puerile doctrine. The real break, however, came when Mivart attacked violently, personally, and mistakenly a rather tentative contribution to eugenics made by George Darwin, Charles Darwin's son. Even in his apology Mivart repeated what Darwin, Hooker, and Huxley considered to be personal libels, and all personal connections between Mivart and the Darwinian group were severed.

Mivart continued to believe in and to teach evolution, but an evolution of limited scope—one compatible with his religion. He remained the leading Catholic scientist in England. Indeed, the liberal Pope, Pius IX, conferred on him the degree of doctor of philosophy in 1876, but during the reaction that followed in the reign of Leo XIII, the Church line hardened and infallible authority stepped in. Mivart refused to accompany his liberal Catholic friends, who were told of their errors and who changed their convictions accordingly. His relations with the Church became strained. The breaking point came when Mivart invaded the field of theology and sought to modify the dogma of eternal punishment. He claimed that eternal torment seemed a trifle excessive for sins committed during a single lifetime, and he held that the Inferno, though very rugged indeed, need not be final, and that even in Hell sinners would be given the opportunity to repent. This was going much too far, and Cardinal Vaughan, Archbishop of Westminster, tended him a confession of faith which he refused to sign. He was excommunicated and died the next year.

Mivart could not be buried in consecrated ground, but 4 years later his body was moved and was finally buried where he would have wanted to be. His family and friends secured this favor by reporting that Mivart had been very sick during the last year of his life and that his delusions about Hell thus were due to illness rather than to sin.

Jacob Gruber has written an exceptionally readable and objective, but sympathetic, life of Mivart, who is presented as a real, three-dimensional human being, opinionated, intellectually cantankerous but, in his personal contacts, kind and pleasant. He had, however, an unyielding conscience, and he always knew that he was right, down to the last detail.

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Reports

Village Solidarity among Turkish Peasants Undergoing Urbanization

Abstract. A group of Anatolian peasants under study are making a smooth adjustment to urban life. This is attributed to a feeling of village solidarity, which is even maintained in the greater Istanbul area. It is questionable whether this phenomenon in underdeveloped countries is detrimental to socioeconomic development, as is generally believed to be the case.

One of the most vexing problems challenging economists and other social scientists devoted to the study of the development of non-Western nations is the nature of the labor force in the urban centers of such countries. Specifically, the enduring attachment of the peasant in the urban setting to his original unit of social organization, be it a tribe, village, or extended family, forms a strong link which does violence to the model of the rural-urban dichotomy constructed by social scientists. What is generally taking place in many of the underdeveloped countries is a ruralization of the cities, where the peasants carry on an essentially rural or folk way of life (*1*, p. 123; *2*; *3*, pp. 35, 181–182). This folk character found persisting among "urbanized" peasants in underdeveloped countries is considered harmful for the development of these countries. A high rate of absenteeism due to a periodic return to the tribe or village, an "uneconomical" expenditure of wages for costly ceremonies and rituals, a penchant for association exclusively with people of the same background, persistence of folk beliefs and traditional kinship roles, and a "nonrational" approach to problems are the findings from which is derived the conventional picture of the peasant as an anomaly in an urban setting.

Despite Turkey's head start in the modernization process, her urbanization problems are, in general, not unlike those of other underdeveloped nations (*4*, pp. 22–28; *5*). Indeed, as late as 1947, one of Turkey's leading economists noted only an imperceptible growth in urbanization since the Kemalist revolution (*6*). However, since 1950 urbanization has caused consternation among many observers of the Turkish scene. In Turkey's case, industrialization financed by private capital, together with changes in the laws governing inheritance and land, was the goal of the Democratic party, which came into power in 1950. These factors seem to be associated with the sudden spurt of urbanization during the past decade (*4*, pp. 1–22; *7*).

Data derived from research among Anatolian peasants who have moved to Istanbul (*8*) conform to the general pattern, delineated above, for peasants in an urban setting. Questionnaires, interviews, and visits, particularly among a group of migrants from a village in eastern Turkey, now living near and working for Robert College, point to a high degree of village solidarity and its concomitants.

Village solidarity is manifested in cooperative labor practices, voluntary associations for mutual aid and recreational activities, and village endogamy. Furthermore, folk beliefs, traditional kinship roles, and an ethos structured on traditional village patterns appear to operate in an urban environment as they did in Yeniköy (the name is fictitious), the village of origin of the group.

One striking example of the in-group feeling possessed by these people of Yeniköy emerges in their near-total obliviousness to their next-door neighbors in the isolated shack town beyond the hills of the Robert College campus where they now live, because, "they are not of our village," as one Yeniköy informant put it. Yet this shack town is composed of only 13 shacks; seven of these are occupied by villagers of Yeniköy. The others are occupied by peasants from a Black Sea village and are built adjacent to the seven shacks of the Yeniköy group.

The people of Yeniköy hold a variety of jobs at Robert College. Their record as a labor force is good, and their rate of absenteeism is lower than that of others employed in the same type of jobs. A remarkable lack of conflict in the Yeniköy peasants' relations with other Turks as well as among themselves was noted. The disparaging generalizations usually made about peasants in urban environments (*1*, pp. 21–22; *3*, pp. 39–44; *4*, p. 26) are not valid for these people.

The paternalistic role which Robert College plays in giving its employees uniforms and providing them with warm lunches and medical care does not vitiate, to any considerable degree, a comparison of Robert College employment practices with those of any industrial firm or factory in Turkey because the latter organizations play a no less paternalistic role. Indeed, one of the earmarks of industries in underdeveloped nations appears to be the paternalistic attitude they take toward their employees—an attitude which, in itself, may hinder the development of self-reliance and independence and the subsequent urbanization of the individual peasant employee.

The very cultural trait—the peasant's attachment to his most meaningful unit of social organization—deplored by the social scientist because it is felt to militate against socioeconomic development is, in this case, operating to promote such development. The Anatolian peasant's attachment to the place and values of his background, contrary to forming an obstruction against economic development, gives him security, helps him adjust to urban life, and may even increase his level of productivity. Final successful integration of the peasant into urban life may well hinge on the degree to which he remains a part of the original unit of social organization. Continued research on this aspect of urbanization should prove highly useful.

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Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

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8 July 1960

Potassium Dihydrogen $D_s L_s$-Isocitrate

Abstract. The monopotassium salt is to be preferred to the lactone as the final product of the synthesis of isocitric acid by the method of Fittig and Miller.

In 1889, Fittig and Miller (*1*) described the synthesis of isocitric acid from sodium succinate and chloral by condensation in the presence of acetic anhydride. The resulting trichloromethylparaconic acid was hydrolyzed with barium hydroxide, and the isocitric acid produced was liberated from the barium salt, dehydrated, and isolated as its lactone. Fittig and Miller's procedure was studied in detail in 1946 by Pucher and Vickery (*2*), and several modifications were found advantageous. A yield of lactone free from alloisocitric lactone of approximately 60 percent was obtained in moderately large-scale operations. Further slight modifications of procedure have since been described by Deutsch and Phillips (*3*) and by Kato and Dickman (*4*), but without improvement in yield or convenience.

The excellent properties of monopotassium L_s-isocitrate obtained from the leaves of plants of the family Crassulaceae (*5*) suggested that the troublesome lactonization step could be avoided if the monopotassium salt were isolated as the final product of the synthesis. It has been found that the yield of trichloromethylparaconic acid can be increased from about 73 percent (*2*) to about 80 percent, and that the reaction goes more smoothly if a liberal excess over 1 molar proportion of chloral is used during the condensation. If hydrolysis of the acid is carried out with an excess of barium hydroxide, and the insoluble barium isocitrate is filtered from the hot solution, most by-products and impurities remain in the filtrate. The monopotassium salt is then easily isolated as described by Vickery and Wilson (*5*).

Trichloromethylparaconic acid is prepared as follows. Twenty grams of anhydrous sodium succinate, 16.0 ml of chloral (33 percent excess over 1 equivalent) and 12.6 ml of acetic anhydride (1 equivalent) are heated in an oil bath for 1 hour at 140°C under a reflux condenser with mechanical stirring. The reaction mixture turns black and becomes viscous, but remains fluid. The tar produced is dissolved in 200 ml of hot water, boiled with 15 g of decolorizing carbon, and the solution is filtered and concentrated *in vacuo* to about 120 ml when separation of sodium salts makes further concentration difficult. The solution is heated to dissolve the salts and 30 ml of concentrated HCl are added. The dark red oil which separates is induced to crystallize by chilling the solution and stirring it with a rod. The mixture is chilled overnight, and the crystals are filtered, pressed down hard in the funnel, and washed with a little ice water. After thorough drying in a vacuum desiccator, the yield is 22 to 24 g (72 to 78 percent). A little more of the acid can be recovered, usually as a few drops of oil, by extraction from the mother liquor with ether. The ether extract is washed with water before being concentrated.

Monopotassium $D_s L_s$-isocitrate is then prepared as follows. The crude crystalline trichloromethylparaconic acid, together with the material extracted by ether from its mother liquor, is added slowly to a hot solution of 120 g (20 percent excess over 6 equivalents) of barium hydroxide octahydrate in 150 ml of water, and the thick suspension of barium isocitrate is boiled under reflux with mechanical stirring for an hour in an oil bath. The boiling hot solution is filtered on Whatman No. 3 filter paper covered with a thick layer of Celite, and the precipitate is washed with boiling water. The barium salt is then suspended in cold water and decomposed with a slight excess of sulfuric acid, and the monopotassium salt is isolated by crystallization at *p*H 3.50 as described by Vickery and Wilson (*5, 6*). The yield of this salt is considerably improved if 25 percent of alcohol is added to the concentrated aqueous solution, but the addition of too much alcohol may lead to contamination of the product with alloisocitrate: yield, 14 to 16 g (49 to 56 percent). Most preparations contain between 49 and 50 percent of potassium L_s-isocitrate as determined by the isocitric dehydrogenase method of Ochoa (*7*). Once recrystallized from hot water after addition of 25 percent of alcohol, the salt is essentially pure. The solution from which the monopotassium salt is isolated contains isocitric acid and alloisocitric acid in the ratio of approximately 10:1 as determined by chromatographic analysis on Dowex 1 by the method of Palmer (*8*) with formic acid as eluent.

Monopotassium $D_s L_s$-isocitrate crystallizes from water in tiny needles which collect in nodular masses and adhere strongly to glass unless the solution is stirred during crystallization. When crystallized slowly from alcohol-containing mother liquors, it forms fascicles of small flattened rhombic needles often aggregated into masses. The salt is soluble in its own weight of water at boiling temperature. The solubility at 0°C of a three-times recrystallized specimen is close to 8 g in 100 ml of water and 1.5 g in 100 ml of 25-percent alcohol. It is thus appreciably more soluble than monopotassium L_s-isocitrate. It decomposes at 175° to 176°C with evolution of gas (*9*).

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7 July 1960

Nucleic Acids in Some Deuterated Green Algae

Abstract. In order to determine whether the replacement of hydrogen by deuterium in living organisms is accompanied by changes in amounts and distribution of the cellular components, a preliminary cytochemical investigation has been made on deuterated *Chlorella vulgaris* and *Scenedesmus obliquus*. Cytoplasmic ribonucleic acid is more widely distributed and occurs in higher quantities in deuterated than in nondeuterated algae. Nuclei of deuterated cells are more irregular in shape, and mitotic figures appear with greater frequency in the deuterated organisms.

As part of a study of the effects of deuterium on biological systems, we have made a cytochemical study of some deuterated green algae. The cultivation of *Chlorella vulgaris* and *Scenedesmus obliquus* in 99.6-percent D_2O under conditions that lead to essentially fully deuterated organisms has been previously described (*1*). The organisms used in the studies described here were grown in D_2O for protracted peri-

ods of months and years. There is thus every reason to believe that the nucleic acids have the same isotopic composition as the D_2O medium and that the deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) are therefore essentially fully deuterated. The organisms were grown on a rotating shaker and therefore usually occurred as single cells.

Deuteration of the algae results in morphological changes. Size measurements were made with an ocular micrometer on cells chosen at random. Both hydrogen- and deuterium-containing *Chlorella vulgaris* are spherical. The deuterated *C. vulgaris* has a mean diameter of $5.42 \pm 0.033\ \mu$ compared with $5.14 \pm 0.041\ \mu$ for the hydrogen (protium) prototype. The deuterated organisms are thus substantially larger than the hydrogen organisms. In the case of *Scenedesmus obliquus*, both size and shape are altered by deuteration. Measurements were made along the widest and the longest parts of the organisms. Deuterated *S. obliquus* had a mean length of $7.99 \pm 0.050\ \mu$ as compared with $6.46 \pm 0.056\ \mu$ for the hydrogen organisms, while the mean widths were $3.91 \pm 0.044\ \mu$ for the deuterated organisms and $4.16 \pm 0.030\ \mu$ for the hydrogen-containing *S obliquus*. The deuterated *S. obliquus* are thus longer and thinner than their prototypes.

Cytochemical reactions were performed after fixation by freeze-substitution. A cell suspension was spread on a slide and immersed in liquid nitrogen. The slide was then rapidly moved to chilled absolute alcohol. The slides could be stored by clearing them in xylene and coating them with paraffin.

Conclusions regarding the amount and distribution of the nucleic acids were based on agreement of results from several staining reactions and extraction procedures.

The nucleic acid stains used were modifications of the following: Azure B (*2*), Feulgen (*3*), Methyl Green (*4*), and pyronin (*4*). Under the conditions which were employed, material that stained with both Methyl Green and with the Feulgen reagent and which was removed by treatment with 0.1-percent deoxyribonuclease (buffered at *p*H 6.5) was regarded as DNA. Pyronin-staining material which was removed by extraction with 0.2-percent ribonuclease (buffered at *p*H 6.0) was regarded as RNA. Azure B stains both sorts of nucleic acids as well as some other basophilic substances. The various basophilic substances are reputed to acquire different colors by Azure B staining. However, the presence of chlorophyll in the algae made determination of exact colors, especially in the blue-green region, difficult. Azure B staining, therefore, was simply regarded as indicative of basophilia.

When such basophilic material was removable by treatment with 5-percent trichloroacetic acid it was regarded as nucleic acid. That portion of the Azure B staining material which was removed by ribonuclease treatment was regarded as RNA. The deoxyribonuclease-removable, Azure B positive material was thought to be DNA.

The enzyme reactions were controlled by treating slides with buffers identical to those in which the enzymes were dissolved under the same conditions of time and temperature. In this study the assumption has been made that the staining characteristics of deuterated compounds are the same as for the corresponding hydrogen compounds. Although this is very likely the case, it is a point that requires verification for more quantitative studies.

A comparison of stained cells of deuterated and nondeuterated algae reveals that staining for both RNA and DNA is less localized in deuterated cells. This is the case for both *Scenedesmus obliquus* and *Chlorella vulgaris*, but the situation is seen in its simplest form in a comparison of deuterated and nondeuterated *S. obliquus*. In nondeuterated *S. obliquus*, DNA (Feulgen, Methyl Green, and Azure B stainable; deoxyribonuclease and trichloroacetic acid extractable) is confined to and fills the peripheral nucleus. The nucleus

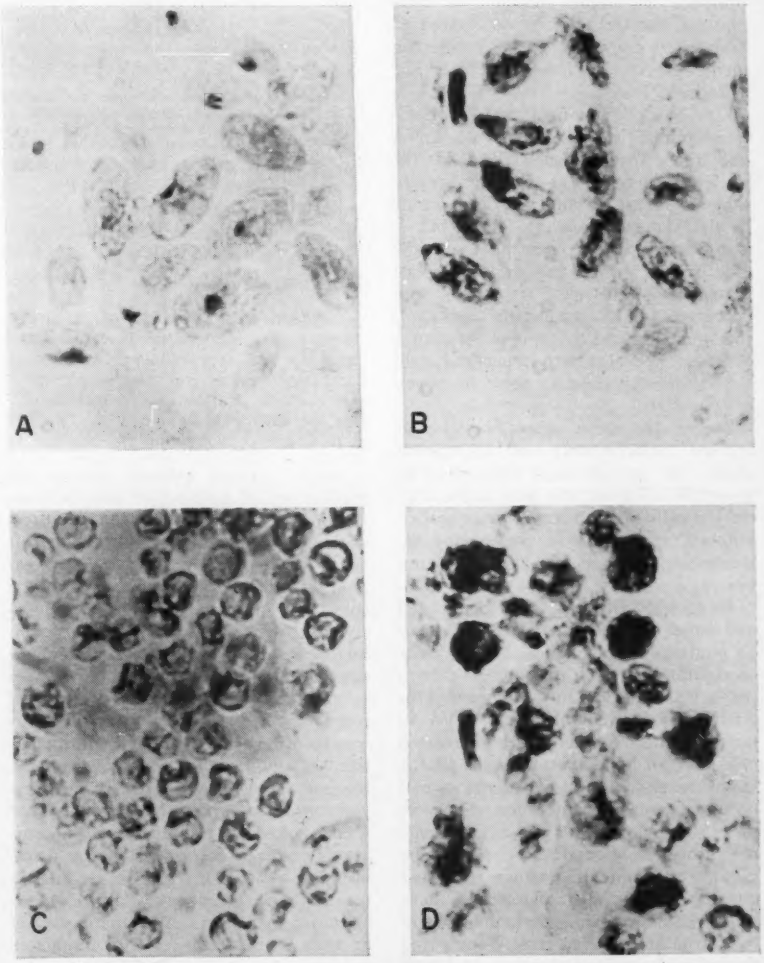

Fig. 1. Algae stained for both DNA and RNA with Azure B (×1700). (*A*) Nondeuterated *Scenedesmus obliquus*. The nucleic acids are largely concentrated in the nucleus. (*B*) Deuterated *S. obliquus*. More cytoplasmic RNA is present and the cell nuclei are more irregularly shaped. (*C*) Nondeuterated *Chlorella vulgaris*. The strongly basophilic peripheral structure is the chloroplast. The nucleus is more centrally located and is stained less intensely than the chloroplast. (*D*) Deuterated *C. vulgaris*. Far more cytoplasmic basophilia occurs than in the nondeuterated organisms.

contains some RNA (pyronin and Azure B stainable; ribonuclease and trichloroacetic acid extractable) as well. The small amounts of cytoplasmic RNA are localized close to the nucleus. In corresponding deuterated cells, the nucleus is larger and appears to contain greater amounts of DNA; more striking than this, however, is the occurrence of far larger amounts of cytoplasmic RNA which is much more widely distributed throughout deuterated cells (Fig. 1, *A* and *B*).

The widespread dissemination of nucleic acids throughout the deuterated cells is also observed in *Chlorella vulgaris*. The chloroplasts of *C. vulgaris*, unlike those of *S. obliquus*, contain (according to the previously mentioned criteria) both DNA and RNA. The presence of larger amounts of cytoplasmic nucleic acids in deuterated *C. vulgaris* as compared to the nondeuterated organisms is clearly visible in Fig. 1 (*C* and *D*).

The basophilia shown in these photomicrographs is caused by both DNA and RNA. In *C. vulgaris* DNA fills the nucleus and occurs at the periphery of the chloroplast. Ribonucleic acid occurs in the same regions as DNA, but is also found more centrally in the chloroplasts and in nonchloroplast cytoplasm. This is true of both deuterated and normal cells. However, the nucleic acid-containing structures of deuterated algae are larger and stain more intensely than do their hydrogen counterparts.

Deuterated algae generally show increased heterogeneity of chloroplast shape. The typical single chloroplast of the nondeuterated cells was, in the deuterated cells of both *S. obliquus* and *C. vulgaris*, replaced by a great many varieties of chloroplast shape and number.

Some individuals in both deuterated and nondeuterated *C. vulgaris* appear to be multinuclear. Occasionally a nuclear configuration which resembles a telophase was observed in *C. vulgaris*. This configuration was observed with so much greater frequency in deuterated cells than in nondeuterated cells that it seems as though nuclear division had been delayed by deuteration. Since in these cells telophase is the easiest stage of mitosis to recognize, it cannot be said at this time that other stages of mitosis are not also affected by deuteration. That the nucleic acid–containing structures have grossly distorted shapes in deuterated algae may be only a reflection of the larger amounts of nucleic acid present, but it is probable that other factors are involved.

Although mitosis appears to be delayed in the algae, it is clearly not prevented. The situation here is clearly different from the arrest of mitosis of *Arbacia* eggs caused by high concentrations of D_2O as described by Gross and Spindel (*5*). But even in the case of the green algae, the effects of isotopic substitution are already evident on the cytochemistry of the organisms (*6*).

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20 June 1960

Staining of Skin with Dihydroxyacetone

Abstract. The reaction of skin with dihydroxyacetone to produce a brown "artificial tan" appears to proceed through combination with free amino groups in skin proteins, and particularly by combination of dihydroxyacetone with the free guanido group in arginine.

Much interest centers around the mechanism of staining of skin by solutions of dihydroxyacetone, a three-carbon keto sugar. Our interest in this sugar arose from observations on excretion of it following ingestion of the substance in a diagnostic test for glycogen-storage disease (*1*). Urine specimens obtained from children after dihydroxyacetone-tolerance tests (*2*) gave several conspicuous spots on chromatograms resolved in isopropanol–ammonia–water solvent treated with diazotized sulfanilic-acid sodium-carbonate reagent (Pauly reagent). No reaction was observed when the same reagent was applied to duplicate chromatograms resolved in butanol–acetic acid–water solvent. This reagent ordinarily reacts with substances which contain an active hydrogen, an aromatic phenol or amine, or substances with imidazole nucleus. An area at R_F 75 (in isopropanol–ammonia–water) turned brown on standing a short time in air, more rapidly on heating. It seemed likely that a reaction occurred between dihydroxyacetone and ammonium hydroxide to form new compounds.

Analyses, by the micro-Kjeldahl method, of areas of the chromatogram which gave positive reactions with Pauly reagent and blank areas indicated that the substance at R_F 75 contained nitrogen. The stability of the reaction products was confirmed when the substances were eluted from chromatograms run in isopropanol–ammonia–water and rechromatographed in butanol–acetic acid–water solvent with no apparent change. Reactions of two principal substances derived from interaction of dihydroxyacetone and ammonium hydroxide are given in Table 1.

These observations led to the conjecture that the staining of skin by dihydroxyacetone might occur through combination with basic groups of skin proteins, or with free amino acids on the surface of the skin. Aqueous solutions of the sugar with ammonium hydroxide alone produced a brown color. The reactions with amino acids and related compounds are shown in Table 2. Arginine was the most reactive, with the appearance of a dark brown color within 30 minutes. Mixtures of dihydroxyacetone with glycine, lysine, and histidine also gave brown to yellow colors.

Chromatography of the mixtures of amino acids with dihydroxyacetone showed that while a positive test for arginine was obtained with ninhydrin, there was no reaction with aniline-phthalate, a sensitive reagent for sugars, at the position usually occupied by dihydroxyacetone. However, in the mixture of arginine and dihydroxyacetone another compound was formed which was positive both with ninhydrin and aniline-phthalate. In the case of glycine at least two additional ninhydrin-positive, aniline-phthalate-positive substances were formed. These reaction products, unlike those obtained from dihydroxyacetone and ammonium hydroxide, did not give a strong positive test with Pauly reagent. Similar observations were made of reaction mixtures of lysine, alanine, proline, and hydroxyproline, even though in

Table 1. Reactions of substances obtained from combination of dihydroxyacetone (DHA) and ammonium hydroxide.

	Substance		DHA
	A	B	
R_F INH*	0.75	0.88	0.70
R_F BuAc†	.48	.70	.60
Pauly reagent	Red-orange	Red	–
Ninhydrin	–	–	–
Aniline-phthalate	–	–	+
Phosphomolybdate	–	–	+
Arsenomolybdate	–	–	+
Brown color on standing in air	+	–	+
N (micro-Kjeldahl)	+	–	–

* Solvent: isopropanol-ammonia-water.
† Solvent: butanol-acetic acid-water.

Table 2. Reactions of aqueous solutions of amino acids in dihydroxyacetone.

Arginine	Immediate yellow; dark brown in 30 min
Glycine	Yellow after 60 min; dark brown in 6 hr
Histidine	Yellow after 60 min; brown in 12 hr
Lysine	Yellow after 60 min
Tryptophane	Yellow after 12 hr
Threonine	Yellow after 12 hr
Alanine	Faint yellow after 12 hr
Valine	No color change
Leucine	No color change
Phenylalanine	No color change

some cases no color change was evident. Additional ninhydrin-positive aniline-phthalate–positive substances were formed in small amounts.

Epidermal proteins have a very high content of basic amino acids, arginine, lysine, and histidine (*3*). Amino acids in sweat (determined by microbiological assay), listed in order of decreasing concentration, are arginine, histidine, threonine, valine, leucine, isoleucine, lysine, phenylalanine, and tryptophane (*4*). Dreizen and associates reported melanoidin formation between degradation products of glucose (dihydroxyacetone and glyceraldehyde) and the organic fraction of tooth structure (*5*). Interaction between amino acids and sugars has been shown to be the cause of browning that occurs in storage of dried foods (*6*). Richards was able to isolate the enolic form of N-(carboxymethyl)-amino-1-deoxyfructose as an intermediate in the browning reaction between glycine and *d*-glucose (*7*). Our data suggest that reactions similar in nature occur between dihydroxyacetone and amino acids. The reaction proceeds more rapidly with the highly reactive dihydroxyacetone.

The presence of arginine and other basic amino acids in skin proteins in relatively high concentration has led to the interesting application of this browning reaction between dihydroxyacetone and skin proteins in cosmetic lotions (*8*).

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7 June 1960

Chromatographic Comparison of Scorpion Venoms

Abstract. The venom of seven species of scorpions was subjected to two-dimensional chromatographic analysis. Six major components were defined and tentatively correlated with the physiological activity of the venoms.

The venom of *Centruroides sculpturatus* Ewing and *Centruroides gertschi* Stahnke has the distinction of exhibiting a severe neurotoxic effect, while that of other scorpions of the Southwest produces little or no systemic effects. These two species also differ in this respect from other species of United States centruroidian scorpions, even though some of the other species morphologically resemble them closely (*1*). *Centruroides sculpturatus* and *C. gertschi* venom also has the distinction of being lethal to man in quantities injected during the process of a single sting.

In cases of moderate to severe venenation, *C. sculpturatus* and *C. gertschi* venom will cause severe drooling, so that the patient loses large quantities of fluids, and characteristic convulsions.

Normally the venom of *Vejovis spinigerus* (Wood) and *Hadrurus arizonensis* (Ewing) apparently produces only a local reaction in the form of a swelling and sometimes ecchymosis at the site of the sting. In severe cases of venenation by these species, reactions of a systemic effect were experienced. This led Palmer (*2*) to investigate the effects of these venoms in larger doses than are injected during the natural stinging process. Among other things, he found that *Vejovis spinigerus* venom in a lethal dose would produce only slight salivation but severe convulsions, while *Hadrurus arizonensis* venom produced severe drooling without convulsions.

The present work is an attempt to characterize chromatographically the proteinaceous components of the venom of seven of these species. The venom from each was collected, lyophilized, weighed, and reconstituted with sterile water to give the concentrations, in milligrams per milliliter, shown in Table 1.

Two - dimensional chromatograms were run on Whatman No. 1 paper squares at 6°C (43°F) with two parts of *N*-propyl alcohol to one part of 1-percent ammonium hydroxide as the first solvent and one part of 1-percent phenol to one part of 1-percent ammonium hydroxide as the second solvent. Two drops from a tuberculin syringe were used as inoculum for all runs.

The ninhydrin-positive pattern was revealed by spraying the strips with 0.2-percent ninhydrin solution in 95-percent ethanol to which 5-percent 2,4,6-collidine was added just before use (*3*).

Table 1. R_F values for seven species of scorpions.

Concn. (mg/ml)	R_F*	R_F†	Component group
	Hadrurus hirsutus (Wood)		
11.5	0.27	0.94	*D*
	.42	.96	*C*
	.65	.90	*B*
	.88	.85	*A*
	Hadrurus arizonensis (Ewing)		
9.9	.46	.96	*C*
	.70	.84	*B*
	.86	.96	*A*
	Centruroides sculpturatus Ewing		
4.63	.12	.97	*E*
	.16	.58	*F*
	.85	.91	*A*
	Centruroides gertschi Stahnke		
0.72	.12	.91	*E*
	.85	.83	*A*
	Centruroides pantheriensis Stahnke		
6.0	.84	.79	*A*
	Centruroides vittatus (Say)		
5.8	.82	.71	*A*
	Vejovis spinigerus (Wood)		
5.6	.90	.71	*A*

* In *N*-propyl alcohol and NH_4OH.
† In phenol and NH_4OH.

The R_F values obtained for the seven species are given in Table 1. Figure 1 shows the distribution pattern of the venom for these seven species. It is apparent that the venom components fall into six areas as designated in Fig. 1.

While some uniformity of venom components is to be expected, the variation in the effect of the sting of differ-

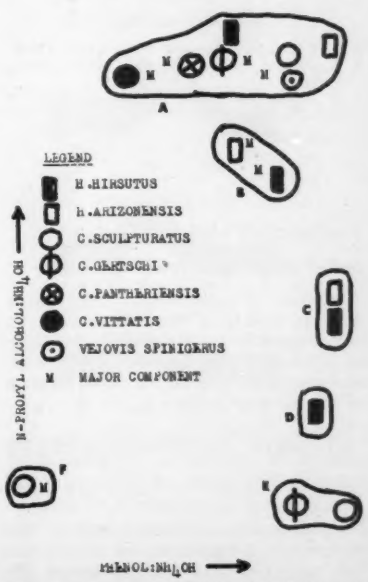

Fig. 1. Chromatographic distribution of scorpion venom into groups. See Table 1 for R_F values.

ent species of scorpions would suggest a similar variation in the constitution of their venom. In this work, such uniformity is found in the area designated as *A* (Fig. 1). Since the chromatograms for all species showed a trailing effect in the *N*-propyl alcohol solution, this was not recorded except for the *Hadrurus* genus, where trailing in the phenol solution definitely indicated unique components. Group *E* was not included in trailing of species other than those designated.

The uniqueness of group *F* in *Centruroides sculpturatus* is significant with regard to the physiological effect of this venom. Group *E*, occurring only in this species and *C. gertschi*, is also significant.

This work would further suggest that the convulsion factor is in group *A*, since it appears as the major component in *C. gertschi* and *Vejovis spinigerus*, while the major component of the *Hadrurus* genus is in group *B*, which could be the salivation factor.

The possibility of synergistic action of these components should not be overlooked. Consequently, small amounts of groups *B*, *C*, and *D* (evidenced by trailing on the chromatograms) in conjunction with component *E* or *F*, or both, could account for this reaction with the venom of *Centruroides sculpturatus* and *C. gertschi*.

Further isolation and purification of these components should establish this relationship.

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20 June 1960

Feeding in Conflict Situations and Following Thwarting

Abstract. It is possible to quantify many different aspects of feeding behavior. In order to specify and differentiate the effects of deprivation levels, conflict, and thwarting, one cannot use only a single measure of this behavior pattern.

Several studies have shown that the concept of drive as an energizer of all behavior that leads to the consummatory response is inadequate to describe the changes in a behavior pattern that accompany a high score in consummatory activities (*1*). Further, Miller (*2*) has reported two conditions that increase the amount of food intake while exerting differential effects on a number of other presumptive measures of strength of hunger. These findings are disturbing, as various investigators who have described the effects of frustration (*3*) and conflict (*4*) as increasing drive strength have estimated the strength of drive by measuring a few, often a different few, of the many quantifiable aspects of a behavior pattern. The present report questions the description of such effects in terms of a unitary intervening variable.

Table 1. Feeding behavior: (*A*) following 1, 2, and 3 days deprivation ($N=9$); (*B*) in successive 15-minute periods of the feeding session, 2 days deprived ($N=9$); (*C*) in conflict sessions with high, medium, and low shock ($N=12$); (*D*) following thwarting ($N=6$). Significant differences: Italic type indicates that the difference between vertically adjacent pairs of numbers is statistically significant. In *A* and *C*, the pairs of asterisks indicate that the difference between the pairs of numbers not vertically adjacent are statistically significant. In *C*, bold-face type indicates that the differences between normal controls and all shock intensity tests considered together are statistically significant.

	Completed	Initiated	Initiated / Completed	Duration completed (0.01 min)	Total time feeding (min)
A. Days deprived					
1	*132*	612	*4.39*	3.8*	21.8
2	*196*	717	*3.52*	*3.3*	21.2
3	*252*	778	*2.87*	*2.8**	21.7
B. Successive 15 min of feeding session					
1st	*63*	*172*	*2.75*	*2.6*	*4.3*
2nd	*54*	*193*	*3.46*	*3.2*	*5.7*
3rd	*43*	182	*3.98*	*3.7*	5.8
4th	*36*	169	*4.50*	4.0	5.6
C. Conflict: normal control; high, medium, low shock					
N	**196**	**756**	**3.83**	**3.3**	**22.8**
High	*125**	*551*	3.27	2.8	13.7*
Md.	*155*	*580*	3.64	3.0	17.5
Low	197*	646	3.36	2.9	19.4*
D. Thwarted and normal control; 1, 2, 3 days deprived					
1, N	155	*536*	*3.12*	4.0	21.3
1, T	180	*686*	*3.44*	4.0	25.8
2, N	191	*557*	2.74	4.0	22.2
2, T	209	*701*	2.98	3.7	25.2
3, N	*223*	577	*2.50*	3.5	*19.3*
3, T	*164*	671	*3.60*	3.9	*25.4*

Three-spined sticklebacks (*Gasterosteus aculeatus*, L.) were maintained in aquaria divided by a partition into a food area and a living area. A portion of the partition was removed to permit 1 hour of access to the food at 1-, 2-, or 3-day intervals. For the thwarted feeding sessions the food was covered by a transparent plate for ½ to 2 hours. After intervals ranging from 3 minutes to 4 hours, access to the food area with the plate removed was allowed. In conflict sessions, the fish received electric shock at varying intensities (42 volts, 84 ma; 66 volts, 112 ma; 108 volts, 210 ma) through a pair of electrodes immersed in the water. The first two entries into the food area or the 10th and 20th grasp at food were the occasions for administering shock.

Tubifex worms were scattered in the food area. Samples taken from the tanks indicated that there were over 30 times as many worms present as the fish would remove in the feeding session. To test whether a change in the behavior of the prey would make them less available to their predators, the feeding responses of the fish were imitated by poising over the prey and touching them with the end of a broad pencil at a rate corresponding to that of the feeding stickleback. There were no significant changes in the reaction of the prey to the repetition of this stimulation.

Sticklebacks feeding on their ground-living prey swim near the floor of the tank and occasionally tilt their bodies to remain poised over the worms which are half-embedded in the sand. The eye movements during fixation on the prey are quite distinctive. Fixations may be followed by grasping the prey, scored as *completed feeding responses*. Each fixation, whether it led to the grasp or not, was scored as an *initiated feeding response*. Behavior such as attacks, returns to the living area, swimming up and down the walls of the food area, and so forth, has been grouped together as a bout of *nonfeeding behavior*. Such activities would appear in the absence of food and their frequency and duration could be changed by varying conditions other than deprivation. Then, *total time spent feeding* measures the predominance of feeding behavior in the 1-hour session, while the *ratio of initiations to completions* measures the predominance of one element in the feeding behavior pattern. In a bout of feeding, it is possible that few completions are performed because the *duration* of feeding responses is very long.

Behavior was recorded on a machine that moved a strip of paper at the rate of 5.6 cm/min (*5*). The frequency,

duration, and order of succession of responses could be obtained from the records.

Increased deprivation time results in a greater number of completed feeding responses, a shortened duration of feeding responses, and a decrease in the ratio of initiated to completed feeding responses (Table 1, *A*, *B*). But neither the number of initiations nor the total time spent feeding is reliably increased by deprivation.

These effects on feeding behavior are reversed in the course of the feeding session, as the fish become satiated: the frequency of completions decreases, response duration becomes longer, and there are more initiations per completion. The time spent feeding and the frequency of initiations increase at the beginning of the feeding session, remain at high values, and then fall off slightly at the end of the hour.

Hunger shows its effects on the predominance of completions over initiations, not on the predominance of feeding behavior over nonfeeding behavior.

In the conflict sessions (Table 1, *C*), the total time spent feeding is below normal values, and more markedly so for increasing shock intensities. But the ratio of initiations to completions is lower than normal, and the duration of feeding responses is below normal. These latter two effects are not changed by increasing shock intensities.

Nonfeeding behavior has become more predominant in the conflict sessions, but when feeding behavior is shown it is like that of very hungry fish (*6*). As a result, over half the fish performed more completed feeding responses than normally under conditions of low shock, with some fish scoring as much as 40 percent over normal values.

As the feeding session progresses, the usual satiation changes occur and deviations from normal feeding scores are less marked. For example, the initiated to completed response ratio is below normal throughout the session, but reliably below normal only for the session as a whole or for the first 15 minutes of the session (*4*).

The effects of thwarting (Table 1, *D*) resemble those of conflict in that the fish may perform more or fewer completed feeding responses than normally. But now total time spent feeding and the frequency of initiations have increased, whereas the initiation to completion ratio is higher than normal.

It is noteworthy that the usual differences in feeding behavior for the three deprivation conditions have disappeared in the tests that follow thwarting.

The effects of thwarting and of conflict must be specified in terms of measures that indicate the predominance of the observed pattern of behavior over its alternatives and the predominance of high and low intensity forms of the behavior pattern. A model linking these two aspects of motivated behavior has been described (*7*, *8*).

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6. The conflict study shows how cessation of feeding occurs. In the course of normal feeding sessions, only increases in time spent feeding were reliable. Though interruptions of feeding involving returns to the living area are few at the end of the session, these are of a reliably longer duration and extend further away from the food area. In the stickleback's normal environment this should increase the likelihood of exposure to stimuli that evoke behavior incompatible with feeding and thus end feeding activities.
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20 June 1960

Changes in Soluble Proteins of Developing Lily Anther

Abstract. The extract of soluble proteins from *Lilium* anthers is characterized by four electrophoretic components. Three of the components show quantitative differences markedly correlated with the synchronized division of the microspores contained within the anthers. One of the components increases in amount before mitosis and disappears at mitosis; two of the components have peak values at the time of mitosis and decrease thereafter; a fourth component remains relatively constant in amount throughout.

In recent years it has become increasingly apparent that many of the major steps of chromosome synthesis take place before the visible events of mitosis. In particular, one may cite the synthesis of deoxyribonucleic acid (*1*–*4*) and of nuclear histones (*3*, *5*). The anthers of *Lilium* are favorable material for investigating relationships of this sort since mitosis of the microspores within the anthers is highly synchronized and precisely correlated with the length of the developing flower bud (*6*). Foster and Stern (*1*), for instance, have shown striking changes in the quantity of soluble deoxyribosides in the anthers, which are correlated with bud length and hence with the mitotic process. The work reported here is a preliminary study by analytical electrophoresis to determine the behavior of the phosphate buffer-soluble fraction of anthers prior to and during mitosis.

Anthers were collected from flower buds of *Lilium longiflorum* cv. 'Croft' of specified lengths and placed in a freezer until samples of sufficient size were obtained. The bud lengths studied were 40 and 50 mm (before mitosis), 60 mm (during mitosis), and 80 mm (after mitosis). A single sample consisted of the anthers from 10 to 15 buds which were within 1.0 mm of the desired length. Each sample was extracted, with the aid of glass homogenizers, in the cold, in a 0.1 ionic-strength phosphate buffer of *p*H 7.0 (*7*). Extracts were centrifuged at about 4000*g* for 0.5 hour, and the supernatants were dialyzed for 18 hours against three changes of buffer. After ultraviolet estimation of the protein concentration, the dark-colored extracts were diluted with buffer to approximately 12 mg/ml to facilitate electrophoretic analysis, and aliquots of these diluted samples were analyzed for protein concentration by the Folin method. The instrument for electrophoresis and the methods of

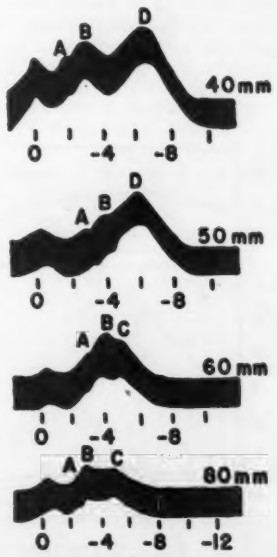

Fig. 1. Descending electrophoresis patterns, at *p*H 7.0, of phosphate buffer-soluble proteins extracted from *Lilium* anthers. Potential gradients were 6.9, 6.8, 7.0, and 6.7 v/cm for the 40-, 50-, 60-, and 80-mm samples, respectively.

analysis which were used have been described previously (*8*).

The electrophoretic diagrams obtained from the anther extracts (Fig. 1) are complex and different for the four bud lengths. Four electrophoretically distinguishable components characterize the extracts, although only three components are detectable in any single-bud-length sample. The differences in the total area displacement of the electrophoretic patterns are relative to the concentration of protein in the samples. As shown in Fig. 2 (upper curve), there is a protein increase prior to mitosis, a decrease through and following mitosis, and a final value of only about one-fourth of the maximum.

Estimations of the actual amounts of protein represented by the individual electrophoretic components are shown in Fig. 2 (lower curve). Of the individual electrophoretic components, the fastest-moving one, *D*, shows the most spectacular change. This non-Gaussian component increases in amount during the premitotic period but is undetectable during mitosis and thereafter. Components *B* and *C* are present in greatest amount at mitosis despite a decrease in the total soluble protein at this time. Component *C* appears to be absent before mitosis, although it may merely be obscured by the large amount of component *D*. Component *B*, however, can be detected in all of the extracts. Component *A*, which is also present in all of the extracts, is unique in that it shows no conspicuous quantitative change.

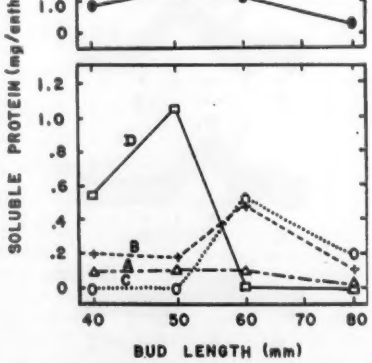

Fig. 2. Changes in the soluble proteins of *Lilium* anthers with increasing flower bud length. (Top) Total values obtained by Folin determination. (Bottom) Values for electrophoretic components based on proportion of the total pattern area represented by individual components. Average electrophoretic mobility (all values $\times 10^{-5}$ $cm^2v^{-1}sec^{-1}$): component *A*, −2.5; *B*, −3.5; *C*, −4.8; and *D*, −6.1.

One may be tempted to speculate that component *D* may in some way be associated with chromosome duplication, since it occurs at very nearly the same bud length at which Foster and Stern (*1, 2*) have described large concentrations of soluble deoxynucleosides. One may further speculate that component *B* or component *C*, or both, which are in highest amount in buds of 60-mm length, may correspond to the spindle protein described by Mazia (*9*). These speculations are hazardous, however, in the absence of any characterization of the components beyond their electrophoretic mobilities. These preliminary studies are being followed by attempts to separate the components by means of cellulose ion-exchange columns. Such separation would make it possible to purify them for further chemical and physical characterization (*10*).

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10. We greatly appreciate the imaginative and constructive suggestions made by Professor R. O. Erickson.

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† Formerly a research associate employed under National Science Foundation grant No. G-4084 to Ralph O. Erickson. *Present address*: Chemistry Department, Morgan State College, Baltimore, Md.

21 June 1960

Boron and Sugar Translocation in Plants

An article entitled "Translocation of particles within plants" by J. W. Mitchell, I. R. Schneider, and H. G. Gauch (*1*) reviewed and discussed an important subject in plant physiology, and the citation of 71 references would suggest that the authors intended to present a critical review of the latest information on the subjects covered. One familiar with the literature on boron, however, is struck by their omission of any reference to published data not in accord with the hypothesis they presented for the role of boron in sugar translocation.

Their discussion of this subject was limited to and centered about a hypothesis initially presented 7 years ago (*2–5*) suggesting that a major function of boron was in the translocation of sugar. They postulated (*2, 3*) that the sugar-borate complex may move from cell to cell or that boron as a constituent of the membrane forms a temporary union with sugar at these sites to effect its passage. They further considered boron-deficiency symptoms such as necrosis of apical buds and root tips to be in reality manifestations of sugar deficiency, in that lack of boron prevents the movement of required sugar to these loci of active growth.

Numerous investigators (*6–12*) have questioned this view, and most of the published evidence has not substantiated the hypothesis of Gauch and Dugger (*2*). Boron-deficient stem apices and root tips, for example, are not sugar-deficient (*6, 7*), nor do sugar applications to terminal regions alleviate boron deficiency symptoms (*5, 6, 9, 10, 13*). Skok (*11*) has critically reviewed this subject and has shown (*10*) that boron may have an apparent but entirely indirect affect on sugar translocation. His experiments suggest that the boron effect is related to cellular activity and growth rather than directly to the formation of a boron-sugar complex. Materials, including sugar, move from leaves to such metabolically active regions as growing tips (*12*). When growth is decreased by lack of boron, movement of sugar to these areas is decreased and the addition of boron might be expected to raise the metabolic rate toward the normal, which in turn results in an increased movement of sugar into these regions. This indirect relationship was demonstrated by measuring the movement of C^{14}-labeled sugar applied to the lower leaves of normal boron-sufficient plants, boron-deficient plants, and normal boron-sufficient plants with their terminal buds excised. The removal of the bud, the actively growing region, reduced the translocation of the applied sugar into the apical part of such plants to 57 percent of that observed in boron-sufficient plants; this was even a greater reduction than that observed in the boron-deficient plants.

I have obtained similar evidence substantiating an indirect relationship between boron and sugar translocation in experiments in which the translocation of C^{14}-labeled sucrose was studied in boron-deficient sunflower plants with and without H_3BO_3 added directly to

the terminal bud (*14*). A significantly greater amount of sucrose was translocated to the terminal portions of plants to which boron had been applied to the terminal buds; in most experiments, however, no difference was found between the two series in the sugar translocated to the roots.

It is certain that many and perhaps most of the details regarding the exact role(s) of boron in plant growth are yet to be uncovered. The final accepted role(s) for this element can only be assigned when all reported data become integrated. Investigators who ignore data only defeat this accomplishment and do an injustice to the general reader not specifically involved or interested in this research area but only desirous of remaining abreast of the subject.

WAYNE J. MCILRATH
Department of Botany, University of Chicago, Chicago, Illinois

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14. This work was supported by National Science Foundation grant G10017 and the Clara A. and Wallace C. Abbott Memorial Fund of the University of Chicago.

18 July 1960

With regard to the criticisms of our recent article entitled "Translocation of particles within plants," we feel that McIlrath may have misunderstood the intent of the article. As we understand it, this series of articles was designed to give the nonspecialist in the field a general presentation of various subjects, together with some typical problems involved. Limitations in space and in the number of citations dictate that the many subjects which are touched on shall be handled without a presentation and discussion of all ideas on the subject and without reference to all the literature which impinges on the topic. We reject the assumption that the 71 references would indicate that we were covering the subject exhaustively, since admittedly hundreds of papers would have been pertinent to so broad a topic as this one which ranged from ions through macromolecules.

With regard to our failing to discuss the various roles of boron, and particularly the evidence which has been interpreted as not supporting the Gauch-Dugger hypothesis, we felt that such a discussion would have been irrelevant to the theme of our article. Each of the three sections (ions, molecules, and macromolecules) was illustrated with a typical piece of research; we chose examples from our own researches about which we were naturally best informed and for which we had illustrative material. For that reason we cited neither the many researches which support the boron concept nor those which did not.

Although a discussion of the pros and cons of the Gauch-Dugger concept would have been irrelevant, the question of evidence against that concept has been raised by McIlrath and thus deserves comment. The junior author (Gauch) assumes responsibility for evaluating this question and does not accept the evidence against the Gauch-Dugger hypothesis presented by McIlrath and his co-workers and that of certain of the papers cited by McIlrath. He recognizes this difference of opinion as honest and healthy for science. Unfortunately it is impossible to present in this space his objections to McIlrath's experimental procedures and to the use of boron-sufficient plants showing boron-toxicity symptoms [W. J. McIlrath and B. F. Palser, *Botan. Gaz.* **118**, 49 (1956); B. F. Palser and W. J. McIlrath, *Botan. Gaz.* **118**, 53 (1956)] as the controls by which the performance of boron-deficient plants was evaluated and the validity of the Gauch-Dugger concept was questioned. Lastly, for the sake of the record and for the nonspecialist, it should be added that there are recent papers which support the Gauch-Dugger hypothesis.

We regret that the intent of the article and our handling of it caused misunderstanding. We trust that we have hereby clarified our intent and that we have explained why we handled this admittedly broad topic the way we did.

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I. R. SCHNEIDER
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H. G. GAUCH
Department of Botany, University of Maryland, College Park

8 August 1960

Association Affairs

Election of AAAS Officers

The AAAS Committee on Nominations and Elections met on 19 August to select candidates for the offices of president-elect and members of the Board of Directors. After considering suggestions received from Council members by mail ballot, the committee nominated the following persons:

President-elect (one to be elected)
Paul M. Gross
William W. Rubey

Members of the Board of Directors (three to be elected)
Theodore C. Byerly
Henry Eyring
Don K. Price
Mina S. Rees
William C. Steere
Alan T. Waterman

Ordinarily there are only two vacancies to be filled on the Board of Directors, but this year, in addition to two members to be elected for regular four-year terms, the Council will elect a third member to complete an unexpired term of one year.

The Board members whose terms expire at the end of 1960 are Don K. Price, Mina S. Rees, and Alan Waterman. Dr. Waterman is completing a full term. Drs. Price and Rees, who have served for two and three years, respectively, were elected to fill vacancies on the Board.

Election procedures established by the Council provide that additional candidates for any of the elective offices may be nominated and included on the ballot by a petition signed by no fewer than 30 members of the Council and submitted to the executive officer no later than 1 November.

Council members will receive ballots for election by preferential mail vote by 10 November. The results of the election will be announced on 27 December at the Association's 1960 annual meeting in New York. Biographical data concerning each of the candidates follow.

Paul M. Gross

Paul M. Gross, 65 (chemistry), instructor in chemistry, College of the City of New York, 1916–18; assistant professor, Trinity College, 1919–20, professor, 1920–24; professor, Duke University, 1925–, chairman of the department, 1926–49, dean of the graduate school, 1947–52, vice president, 1949–60, dean of the university, 1952–58; president, Oak Ridge Institute of Nuclear Studies, 1949–; president, Council of Southern Universities, 1952–53; treasurer, 1953–; member, National Science Board, 1950–; vice chairman, National Science Foundation, 1955–; member, Picatinny Arsenal Advisory Council, 1950–; member, Ordnance Corps Advisory Committee, 1958; member, National Cancer Advisory Council, National Cancer Institute, 1959–; chairman, Senior Scientists Steering Group, Office of Ordnance Research, 1958–; awarded Herty Medal, 1945; President's Medal of Merit, 1948; Townsend Harris Medal, 1953; Honorary Commander, Order of British Empire, 1958.

AAAS activities: member, Board of Directors, 1955–58; member, Committee on Publications, 1957–58.

Paul M. Gross

William W. Rubey

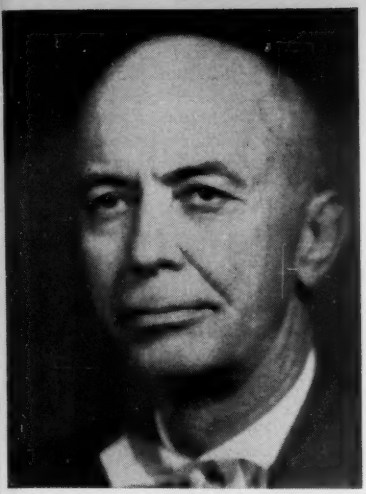
William W. Rubey

William W. Rubey, 61 (geology), instructor in geology, Yale University, 1922–24; geologic aide to principal geologist, U.S. Geological Survey, 1920–44, geologist in charge, division of areal geology and basic sciences, 1944–47, research geologist, 1947–60; professor of geology and geophysics, University of California (Los Angeles), 1960–; chairman, division of geology and geography, National Research Council, 1943–46, general chairman, 1951–54; president, Geological Society of America, 1949–50; vice president, American Geological Institute, 1950–51 and 1958–59; member, National Science Board, 1960–; member, Board of Directors, Geochemical Society, 1955–57; councillor, American Philosophical Society, 1956–59; visiting professor of geology, Institute of Geophysics, University of California (Los Angeles), 1954, California Institute of Technology, 1955, Johns Hopkins University, 1956.

AAAS activities: member, Board of Directors, 1957–; member, Committee on Section E, 1939–42; member, Newcomb Cleveland Prize Committee, 1951, 1958, and 1959; representative on Science Service Board of Directors, 1956–; member, Executive Committee, 1958–59.

Theodore C. Byerly

Theodore C. Byerly, 58 (physiology), instructor in zoology, University of Michigan, 1926–28, Hunter College, 1928–29; physiologist and later senior poultry husbandman, Bureau of Animal Industry, U.S. Department of Agriculture, 1929–37, chief, poultry husbandry investigations, 1941–47, head, animal husbandry division, 1947–53; professor of poultry husbandry, University of Maryland, 1937–41; chief, animal and poultry husbandry research branch, Agricultural Research Service, 1953–55, assistant director of livestock re-



Theodore C. Byerly

Henry Eyring

Don K. Price

search, 1955–57, deputy administrator for farm research, 1957–; received Borden Award, 1943.

AAAS activities: Council member, 1957–59; member, Committee on the Social Aspects of Science, 1957–58; member, Committee on Science in the Promotion of Human Welfare, 1959–.

Henry Eyring

Henry Eyring, 59 (chemistry), instructor in chemistry, University of Arizona, 1924–25; teaching fellow, University of California, 1925–27; instructor, University of Wisconsin, 1927–28, research associate, 1928–29; lecturer, University of California, 1930–31; research associate, Princeton University, 1931–36, associate professor, 1936–38, professor, 1938–46; dean of the graduate school, University of Utah, 1946–; director of fundamental research, Textile Foundation, Textile Research Institute, 1944–46; awarded AAAS Newcomb Cleveland Prize, 1932; Research Corporation Award, 1949.

AAAS activities: vice president and chairman, Section C, 1945–46; president, Pacific Division, 1959.

Don K. Price

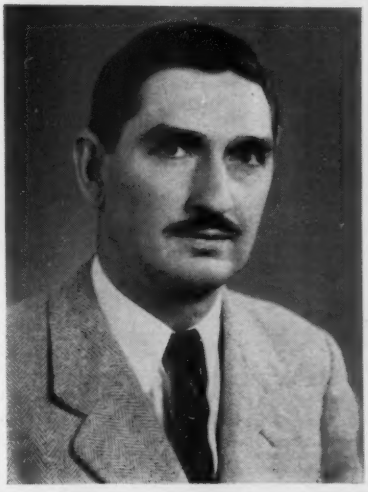
Don K. Price, 50 (political science), research assistant, Home Owners' Loan Corporation, 1935–37; staff member, committee on public administration, Social Science Research Council, 1937–39; editorial associate, Public Administration Clearing House, 1939–41, assistant director, 1941–43, associate director, 1946–53; staff member, U.S. Bureau of the Budget, 1945–46; deputy chairman, Research and Development Board, U.S. Department of Defense, 1952–53; lecturer, political science, University of Chicago, 1946–53; associate director, Ford Foundation, 1953–54, vice president, 1954–58; dean, Graduate School of Public Administration, Harvard University, 1958–; assistant to Herbert Hoover, Study of the U.S. Presidency, 1947–48; member, Board of Directors, Social Science Research Council, 1949–52; staff director, Committee on Department of Defense Organization, 1953.

AAAS activities: member, Board of Directors, 1959–60.

Mina S. Rees

Mina S. Rees, 58 (mathematics), instructor, Hunter College, 1926–32, assistant professor, 1932–40, associate professor, 1940–50, professor and dean of faculty, 1953–; technical aide, administrative assistant to chief of applied mathematics panel, Office of Scientific Research and Development, 1943–46; head, mathematics branch, Office of Naval Research, 1946–49, director, mathematical sciences division, 1949–52, deputy science director, 1952–53;

Mina S. Rees



William C. Steere

Alan T. Waterman

WATER FOR INDUSTRY

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member, Mathematics Policy Committee, 1952–53; member, mathematics division, National Research Council, 1953–56, executive committee, 1954–56; member, general sciences advisory panel, Department of Defense, 1957–; member, advisory commission for mathematics, National Bureau of Standards, 1954–60, chairman, 1954–57; member, advisory panel for mathematical sciences, National Science Foundation, 1955–58; member, Council, New York Academy of Sciences, 1956–59; member, Conference Board of the Mathematical Sciences, 1960–.

AAAS activities: vice president and chairman, Section A, 1954; member, Board of Directors, 1958–60.

William C. Steere

William C. Steere, 53 (botany), instructor in biology, Temple University, 1929–31; instructor in botany, University of Michigan, 1931–36, assistant professor, 1936-42, associate professor, 1942–46, professor, 1946–50, chairman of the department, 1947–50; professor of biology, Stanford University, 1950–58, dean of the graduate division, 1955–58; director, New York Botanical Garden, 1958–; professor of botany, Columbia University, 1958–; exchange professor, University of Puerto Rico, 1939–40; senior botanist, U.S. Board of Economic Warfare Cinchona Missions, Colombia, 1942–43, Ecuador, 1943–44; senior botanist, Alaska Terrain and Permafrost Section, U.S. Geological Survey, 1949–54; program director, systematic biology, National Science Foundation, 1954–55; president, American Bryological Society, 1936–37; president, American Society of Naturalists, 1957–58; president, Botanical Society of America, 1959; president, American Society of Plant Taxonomists, 1959; editor-in-chief, *The Bryologist*, 1938–54; editor, *American Journal of Botany*, 1953–57.

AAAS activities: vice president and chairman, Section G, 1948; member, Committee on AAAS Meetings, 1959–; committeeman-at-large, Section G, 1959–.

Alan T. Waterman

Alan T. Waterman, 68 (physics), instructor in physics, University of Cincinnati, 1916–17; Yale University, 1919–23, assistant professor, 1923–30, associate professor, 1931–48; vice chairman, division D, National Defense Research Committee, 1942–43; deputy chief, office field service, Office of Scientific Research and Development, 1943–45, chief, 1945–46; chief scientist, planning division, Office of Research and Inventions, 1946; deputy chief and chief scientist, Office of Naval Research, 1947–51; director, National Science Foundation, 1951–; member, Editorial Board, *American Journal of Science;* awarded Presidential Medal for Merit, 1948; first annual Captain Robert Dexter Conrad Award by the Office of Naval Research, 1957; Public Welfare Medal of the National Academy of Sciences, 1960.

AAAS activities: vice president and chairman, Section B, 1955; member, Board of Directors, 1957–60.

Forthcoming Events

October

19–20. American Geophysical Union, Moscow, Idaho. (W. E. Smith, 1515 Massachusetts Ave., NW, Washington 5, D.C.)

19–21. Design of Experiments, 6th conf. (by invitation only), Aberdeen Proving Ground, Md. (F. G. Dressel, Office of Ordnance Research, Box CM, Duke Station, Durham, N.C.)

19–21. Space Navigation, symp., Columbus, Ohio. (Institute of Radio Engineers, 1 E. 79 St., New York 21)

20–21. Hypervelocity, symp., Denver, Colo. (R. R. Dexter, IAS, 2 E. 64 St., New York 21)

20–22. Acoustical Soc. of America, San Francisco, Calif. (V. Salmon, Stanford Research Institute, Menlo Park, Calif.)

20–22. Institute of Management Sciences, 7th intern., New York, N.Y. (J. Townsend, IMS, 30 E. 42 St., New York 17)

21–22. Association of Midwestern College Biology Teachers, 4th annual, Mankato, Minn. (L. Zell, Mankato State College, Mankato, Minn.)

21–22. Research Approaches to Psychiatric Problems, symp., Galesburg, Ill. (T. T. Tourlentes, Galesburg State Research Hospital, Galesburg)

21-23. American College of Cardiology, St. Louis, Mo. (G. F. Greco, 114–08 Linden Blvd., Ozone Park 16, N.Y.)

21–25. American Heart Assoc., annual, St. Louis, Mo. (AHA, 44 E. 23 St., New York 10)

22. Midwest Solid State Conf., 8th annual, Lincoln, Neb. (J. W. Weymouth, Physics Dept., Univ. of Nebraska, Lincoln)

23–26. American College of Gastroenterology, Philadelphia, Pa. (D. Weiss, 33 W. 60 St., New York 23)

24–26. Medical and Biological Aspects of the Energies of Space, symp. (School of Aviation Medicine, USAF Aerospace Medical Center), San Antonio, Tex. (J. Harmon, Symposium Coordinator, Southwest Research Inst., P.O. Box 2296, San Antonio 6)

24–27. Hot Atom Effects, symp., Prague, Czechoslovakia. (International Atomic Energy Agency, 11 Kärntner Ring, Vienna 1, Austria)

25–27. American Standards Assoc., natl. conf., New York, N.Y. (G. F. Hussey, Jr., AST, 70 E. 45 St., New York 17)

26–28. Animal Care Panel, 11th annual, St. Louis, Mo. (ACP, P.O. Box 299, Lemont, Ill.)

26–28. Society for Industrial Microbiology, Conf. on Antimicrobial Agents, Washington, D.C. (SIM, 2000 P St., NW, Washington 6)

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Program Content

1. The two-session AAAS General Symposium, "Moving Frontiers of Science V"—Speakers: Edward Anders, H. W. Magoun, George Wald, and H. H. Goldstine; Thomas Park, presiding.
2. The "Challenge to Science" evening with Sir Charles P. Snow, Theodore M. Hesburgh, and W. O. Baker; Warren Weaver, presiding.
3. On "AAAS Day," the three broad, interdisciplinary symposia—Plasma: Fourth State of Matter; Life under Extreme Conditions; and Urban Renewal and Development, arranged by AAAS Sections jointly.
4. The Special Sessions: AAAS Presidential Address and Reception; Joint Address of Sigma Xi and Phi Beta Kappa by Polykarp Kusch; the Tau Beta Pi Address; National Geographic Society Illustrated Lecture; and the first George Sarton Memorial Address by René Dubos.
5. The programs of all 18 AAAS Sections (specialized symposia and contributed papers).
6. The programs of the national meetings of the American Astronomical Society, American Nature Study Society, American Society of Zoologists, History of Science Society, National Association of Biology Teachers, Scientific Research Society of America, Sigma Delta Epsilon, Society for General Systems Research, Society for the Study of Evolution, Society for the History of Technology, Society of Systematic Zoology, and the Society of the Sigma Xi.
7. The multi-sessioned special programs of the American Association of Clinical Chemists, American Astronautical Society, American Geophysical Union, American Physiological Society, American Psychiatric Association, American Society of Criminology, Association of American Geographers, Ecological Society of America, Mycological Society of America, National Science Teachers Association, New York Academy of Sciences—and still others, a total of some 90 participating organizations.
8. The four-session program of the Conference on Scientific Communication: The Sciences in Communist China, cosponsored by the AAAS, NSF, and ten societies.
9. The sessions of the Academy Conference, the Conference on Scientific Manpower, and the conference of the American Council on Women in Science.
10. The sessions of the AAAS Cooperative Committee on the Teaching of Science and Mathematics, and of the AAAS Committee on Science in the Promotion of Human Welfare.
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28–29. Society for the Scientific Study of Religion, 20th, New York, N.Y. (W. H. Clark, Hartford School of Religious Education, Hartford 5, Conn.)

29–3. Photoelasticity, intern. symp., Chicago, Ill. (P. D. Flynn, ISP, Illinois Inst. of Technology, Chicago 16)

31–2. Association of Military Surgeons of the U.S., Washington, D.C. (R. E. Bitner, Suite 718, New Medical Bldg., 1726 Eye St., NW, Washington)

31–2. Electrical Techniques in Medicine and Biology, 13th annual conf., Washington, D.C. (G. N. Webb, Room 547, CSB, Johns Hopkins Hospital, Baltimore 5, Md.)

31–2. Geochemical Soc., Denver, Colo. (K. B. Krauskopf, Geology Dept., Stanford Univ., Stanford, Calif.)

31–2. Geological Soc. of America, Denver, Colo. (F. Betz, Jr., 419 W. 117 St., New York 27)

31–2. Society of Economic Geologists, Denver, Colo. (H. M. Bannerman, U.S. Geological Survey, Washington 25, D.C.)

31–2. Society of Rheology, annual, Pittsburgh, Pa. (J. H. Dillon, Textile Research Inst., Princeton, N.J.)

31–4. American Public Health Assoc., San Francisco, Calif. (B. F. Mattison, APHA, 1790 Broadway, New York 19)

November

1–3. International Cong. on Experimental Mechanics, New York, N.Y. (R. Guernsey, Jr., Soc. of Experimental Stress Analysis, General Engineering Lab., General Electric Co., Schenectady 5, N.Y.)

1–16. International Electrochemical Commission, New Delhi, India. (American Standards Assoc., 70 E. 45 St., New York 17)

2–4. Plasma Physics, 2nd annual, Gatlinburg, Tenn. (A. H. Snell, Oak Ridge Natl. Lab., Oak Ridge, Tenn.)

2–4. Society for Experimental Stress Analysis, Berkeley, Calif. (W. W. Murray, Massachusetts Inst. of Technology, Cambridge)

2–5. American Soc. of Parasitologists, Los Angeles, Calif. (F. J. Kruidenier, Zoology Dept., Univ. of Illinois, Urbana)

2–5. American Soc. of Tropical Medicine and Hygiene, Los Angeles, Calif. (R. B. Hill, 3573 St. Gaudens Rd., Miami 33, Fla.)

2-5. American Speech and Hearing Assoc., Los Angeles, Calif. (K. O. Johnson, 1001 Connecticut Ave., NW, Washington 6)

3–4. Electrostatic Propulsion, conf., Monterey, Calif. (J. M. Sellen, Thompson Ramo-Wooldridge, Inc., 8433 Fallbrook Ave., Canoga Park, Calif.)

3–4. Muscle as a Tissue, conf., Philadelphia, Pa. (Division of Research, Lankenau Hospital, Philadelphia 31)

4–5. West-Central States Biochemical Conf., Lincoln, Neb. (J. H. Pazur, Dept. of Biochemistry and Nutrition, Univ. of Nebraska, Lincoln)

4–6. Assoc. of Clinical Scientists, Washington, D.C. (R. P. MacFate, 54 W. Hubbard St., Chicago 10, Ill.)

5. Society for Industrial and Applied Mathematics, Philadelphia, Pa. (G. Kaskey, Remington Rand Univac, 1900 W. Allegheny Ave., Philadelphia)

7–10. Society of Exploration Geophysicists, 30th annual intern., Galveston, Tex. (C. C. Campbell, Box 1536, Tulsa, Okla.)

8–10. Forensic Sciences, 2nd symp., Washington, D.C. (Director, Armed Forces Inst. of Pathology, Washington 25)

9–10. Use of Secondary Surfaces for Heat Transfer with Clean Gases, symp., London, England. (Secretary, Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1)

9–11. Clinical Chemistry Methods, symp., Cleveland, Ohio. (A. Hainline, Cleveland Clinic, 2020 E. 93 St., Cleveland 6)

10–12. Geological Soc. of America, 73rd conv., Denver, Colo. (H. R. Aldrich, GSA, 419 W. 117 St., New York 27)

10–12. National Assoc. of Geology Teachers, Denver, Colo. (F. Foote, Dept. of Geology, Williams College, Williamstown, Mass.)

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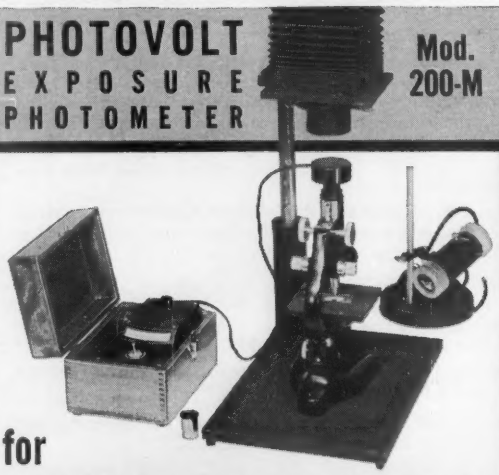

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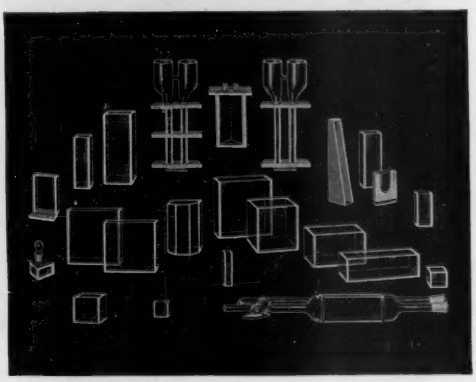

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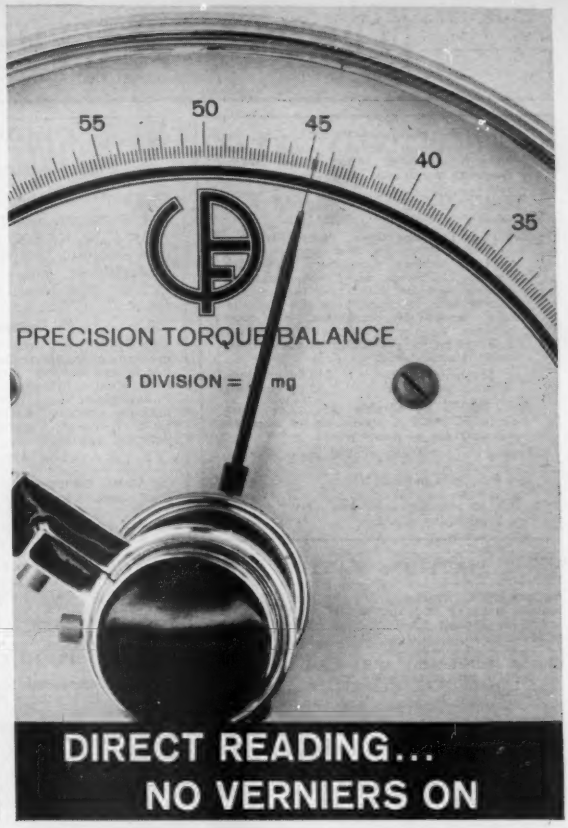

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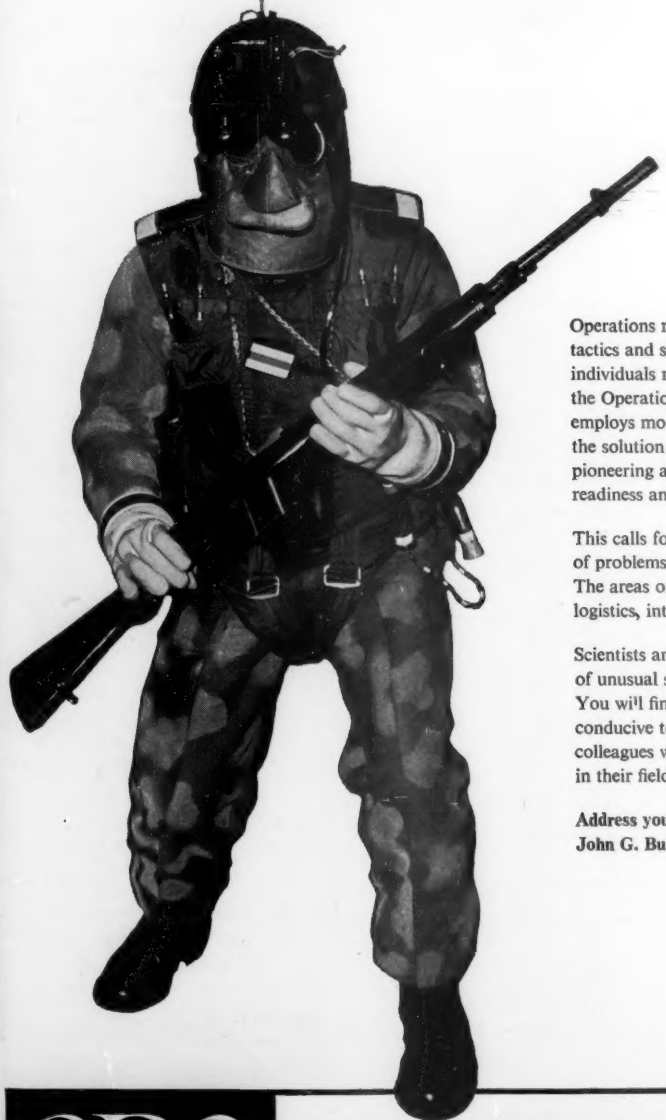

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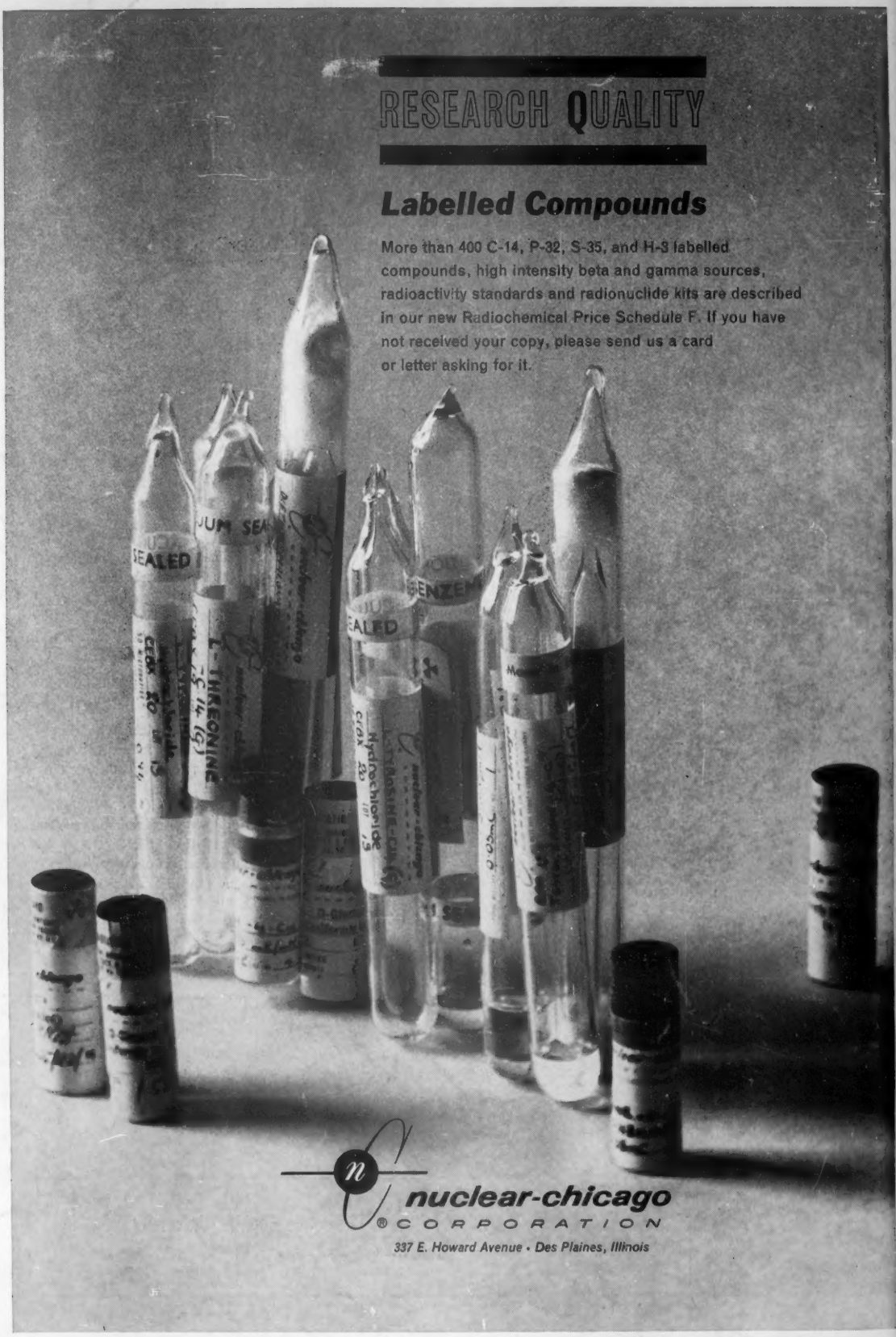
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